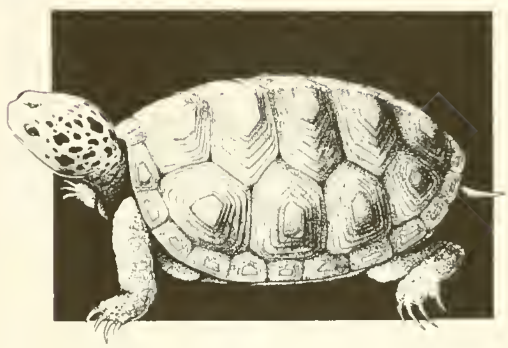

Bryan Patterson

A HISTORY

OF

BRITISH FOSSIL REPTILES.

BY

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A HISTORY

OF

BRITISH FOSSIL REPTILES.

THE

FOSSIL REPTILIA OF THE LIASSIC FORMATIONS.

CHAPTER I. ORDER—SAUROPTERYGIA, *Owen.*

Genus—PLESIOSAURUS, *Conybeare.*

Species—*Plesiosaurus dolichodeirus,* Conybeare.

(TABS. I—IV.)

OF the *Plesiosaurus dolichodeirus,* Conyb., the first described and the typical species of the genus, three more or less entire specimens have come under my observation, which have been obtained from the Lower Lias of Lyme Regis and Charmouth, Dorsetshire. One of these, formerly in the possession of the late Duke of Buckingham and now in the British Museum, was the subject of Conybeare's original description.* A second, in the British Museum, is figured by Buckland in his 'Bridgewater Treatise,' vol. ii, pl. xix, fig. 2; the third, also in the British Museum, is the one which I have selected for illustration in the present CHAPTER (Tabs. I and II). In this the vertebral series is entire; there is no break in the long cervical region, as in the other two specimens; its perfection, in this respect, satisfactorily shows that the head is at, or nearly at, the correct distance from the trunk, with the neck outstretched, in the two former specimens, the greater completeness of which, in regard to the limbs, supplies what is wanting in this respect in the present skeleton (see Tab. I, figs. 2 and 3).

The condition of the vertebral column in the originally described or type-specimen of the *Plesiosaurus dolichodeirus* is such as to suggest that the carcass, after it sank to

* 'Transactions of the Geological Society,' 2nd series, vol. i, p. 381, pl. xlviii.

the bottom, had been preyed upon by some contemporary carnivorous marine animals. It seems as if a bite of the neck had pulled out of place the eighth to the twelfth vertebræ. Those at the base of the neck have been scattered and displaced, as if through more "rugging and riving." Some creature which has had a grip of the spine, near the middle of the back, has pulled to one side all the succeeding vertebræ of the pelvis; their adhesion to that part and, more or less, to each other, being retained. This wrench would expose the abdominal viscera, *à tergo,* where we now see the upper or inner surface of the abdominal ribs or sterno-costal arches. The intermediate and succeeding portions of the vertebral column retain their natural relative positions, as in the prone position of the carcass; and the skull, scapular arch and appendages, pelvic arch and appendages, and the tail, show respectively their relative positions as in the entire animal. Many of the otherwise undisturbed vertebræ, however, have turned, so as to present their most extensive surface to the direction of the slow, cosmical, compressing force operating on their imbedding stratum.

This is the case with the first twenty cervical vertebræ in the specimen Tab. I, which appears to have settled in the Liassic mud back downwards, their spines being turned toward the right side; beyond the twenty-first cervical the vertebræ have rotated in the opposite direction, presenting more or less of a side view, with the neural arch and spine turned to the left; but most of the spinous processes have been removed with the matrix in the original exposure of the specimen. The trunk preserves the supine position, exposing the broad coracoids (52), and pubes (64), with scattered, intervening, abdominal ribs. Part of the left pectoral fin (53—56) is *in situ;* a smaller part of the corresponding pelvic fin (65—67) lies across the pelvis.

No partial force has operated after interment to dislocate any of the vertebræ, save the few terminal ones of the tail, which have disappeared, probably dragged away with whatever tegumentary expansion may have there represented a caudal fin.

In the specimen figured by Dr. Buckland * the skeleton, as it is exposed to view, lies prone; the vertebræ, whilst their matrix was in the state allowing them to turn, have presented their largest surface to the direction of superincumbent pressure, the spines of those at the basal half of the neck being turned down or toward the right side, while those of the dorsal vertebræ have yielded in the opposite direction, both kinds presenting more or less of a side view. The thoracic ribs have slipped some way from their articulations, yet preserve, in the main, their relative positions, in serial succession. The anterior dorsals overlie the coracoids, and the posterior dorsal and sacral vertebræ overlie the dislocated parts of the pelvis. One of the thickened, short, and straight sacral ribs abuts against the right ilium. Upwards of thirty caudal vertebræ extend, in nearly a straight line, from the sacrum. The vertebræ at the fore part of the neck have been displaced, and in great part lost. Of the head little is visible, save the mandibular rami. The bones of both fore and hind paddles on the

* Op. cit., vol. ii, plate x, fig. 2.

right side are in an instructive state of preservation, especially those of the hind fin, which exemplifies the slight superiority of length as compared with the fore fin, characteristic of the present species.

The following are admeasurements of corresponding parts of the three skeletons above mentioned, that of "entire length" being now capable of being given by reason of the integrity of the cervical region of the spine between the head and the pectoral or scapulo-coracoid arch.

	Conybeare's specimen. Ft. in. lines.	Buckland's specimen. Ft. in. lines.	Specimen Tab. I. Ft. in. lines.
Entire length (two or three inches of the tail wanting?)	9 5 0	9 8 0	8 9 0
Length of head	0 8 6*	0 8 2	0 8 6†
,, neck	4 0 0	4 10 0‡	4 10 0
,, trunk, from fore part of sternum to end of ischium	3 0 0	3 6 0	2 8 0
,, tail	2 0 0	2 4 0	(imperfect.)
,, pectoral limb	1 10 0	1 9 0	(imperfect.)
,, pelvic limb	2 0 0	2 2 0	(imperfect.)
,, humerus	0 7 0	0 7 6	0 7 6
,, femur	0 7 0	0 7 4	(wanting.)
,, radius	0 3 0	0 3 0	0 3 6
,, tibia	0 3 0	0 3 3	
,, manus	1 0 0	1 0 0§	
,, pes	1 2 0	1 3 0	
Breadth of pubis (transverse diameter)	0 5 0	(obscured)	0 6 0
Length of ischium (longitudinal diameter)	0 4 6	(obscured)	0 5 0

From the amount of concordance in the dimensions of the above three skeletons, it may be inferred that the average length of the mature animal of the present species of *Plesiosaurus* was between nine and ten feet. Two specimens of certain portions of the skeleton, now in the British Museum, one of which is the subject of Tab. III, support this conclusion.

Vertebral characters (Tabs. III and IV).

Cervical series.—The cervical vertebræ of the *Plesiosaurus dolichodeirus*, at the fore part of the neck (Tab. III, fig. 1, *a*, *c* 4—7), have the centrum (*c*) of a length equalling the breadth of the articular end; but the dimension of breadth increases in a greater

* Estimated at that of the lower jaw.

† Nine inches, if the angle of the jaw be restored, as dotted in Tab. II.

‡ It may be that the head has been drawn a little forward in the displacement of the anterior cervical vertebræ.

§ Some of the terminal phalanges are here estimated for.

ratio as the vertebræ enlarge and recede in position; so that the length of the centrum may be one sixth less than the breadth at the middle (Tab. III, figs. 4, 5, 6) and hind part of the neck. There are, however, varieties in this respect, and the equality of length to breadth of centrum is maintained through a greater extent of the neck in some specimens than in others. The vertical diameter of the middle of the terminal articular surface (ib., fig. 6 *c*) is less by nearly one fourth than the breadth of the same. The sides of the centrum are longitudinally concave (ib., fig. 5), as is also the under part (ib., fig. 4), but in a minor degree in the middle and posterior than in the small anterior cervicals (ib., fig. 1, *c*).

The costal surface is at the lower part of the side of the centrum; it is narrow vertically, in proportion to its length in the anterior cervicals, but gains in vertical extent without being elongated in the same degree, and consequently occupies a larger corresponding extent in the middle cervicals (ib., fig. 4, *pl*),* in which the costal surface exceeds one half the length of the centrum; it is divided by a longitudinal cleft, and is situated a little nearer the posterior than the anterior surface of the centrum. In the third to the seventh cervicals (ib., fig. 1, c 7) the costal surface is separated by a tract exceeding its own vertical diameter from the neurapophysial surface (ib., fig. 1, *n*); in the succeeding cervicals the intervening tract equals the costal surface (ib., fig. 4, *c*); and the interval is never less, and is sometimes more, in the cervical vertebræ to near the base of the neck. The terminal articular surface (ib., fig. 6) is moderately convex at its periphery and very gently concave in the rest of its extent, with a small central, often transversely linear, impression in the centre.†

The free surface of the centrum is finely rugose in the smaller anterior cervicals, and is not smooth in any of the others; towards the articular ends the roughness is more marked, by irregular narrow risings and groovings, which become more longitudinal in direction in the succeeding cervicals (ib., figs. 4, 5). The under surface (fig. 5) is concave transversely from the costal pit (*pl*) to the two venous openings, and is convex between those openings, which divide the surface pretty equally into three parts, Lengthwise, as already stated, the under surface is gently concave. The neurapophysial surface is less angular than in some other species, the lower angle being rounded off, making the lower border approach to a curve. Anchylosis of the neural arch with the centrum seems to have been complete in the anterior cervicals of the specimen figured in Tab. III, fig. 1; and I have not yet seen a cervical centrum of the present species from which the neural arch had become detached, save by fracture. The zygapophyses are proportionally large; the anterior ones (ib., *z*, *z*) extend forward, in the anterior vertebræ almost immediately above the centrum, overhanging the

* Here obscured by the confluent base of the rib.

† "The concavity again slightly swelling in a contrasted curve near the middle of the circular area," (Conybeare's first Memoir, p. 582, April, 1821) is the character of the terminal articular surface in the *Plesiosaurus arcuatus*, from the Lias in the neighbourhood of Bristol.

posterior two fifths of the centrum in advance; the articular surface, the length of which equals two thirds that of the length of the centrum, looks obliquely upward and inward; that of the posterior zygapophysis has the reverse aspect. As the cervicals approach the back the zygapophyses diminish in relative size, and their articular surfaces become less horizontal. The posterior zygapophysis (Tab. III, fig. 4, *z'*) overhangs a small part of the end of the succeeding centrum, and the neurapophysis (ib., fig. 4, *n*) rises with a deeper concavity at the back than at the fore part. That this anchylosis had not occurred in the similarly sized and in the larger specimens of the cervical vertebræ of the *Plesiosaurus* described and figured by Conybeare in his first famous Memoir* is due to their having been derived from a younger specimen of a larger species from the Bristol Lias, probably *Plesiosaurus arcuatus.*

The neural spine (Tab. I, *ns*; Tab. III, fig. 4, *ns*) arises narrow between the bases or back part of the prezygapophyses (*z*), and its base extends, increasing in thickness gradually to near the back part of the postzygapophyses (*z'*). The height of the spine averages half the vertical extent of the entire vertebra from its summit to the lower level of the centrum, being rather shorter in the anterior cervicals and exceeding that length at the base of the neck. In the anterior cervicals the contour of the neural spine extends from the fore part of the base, in a curve increasing in convexity at the upper part, and terminating by a rounded apex overhanging, in the foremost vertebræ (as at c 4, Tab. III), the concave contour of the hinder border. The upper part of the spine becomes more squared as the spine itself gains in height, in the larger posterior cervicals, by the increasing fore-and-aft extent of their upper part, as in fig. 4, *ns*.

The pleurapophysis of the axis (Tab. III, fig. 1, *x pl*) has its posterior angle extended backward; that of the third cervical has its anterior angle also produced forward, but in a minor degree. Both angles continue to be more produced in the succeeding vertebræ, but the front one most so, until, in the fifth cervical, they are equal in length; the hinder one then elongates, but they do not touch or overlap the contiguous pleurapophyses until about the tenth cervical vertebra. The extent of this terminally dilated or extended border of the riblet exceeds that of the diameter of the same from its upper articulation outward or downward. The line of articulation is discernible in most of the anterior vertebræ, but in fig. 1 coalescence has commenced, if it be not complete, as in figs. 4, 5, 6, *pl*, in which the expanded part of the pleurapophysis has been broken off, showing the approximated head and tubercle adapted respectively to par- and di-apophysial divisions of the costal surface. In

* "Notice of the discovery of a new fossil animal, forming a link between the Ichthyosaurus and Crocodile, together with general remarks on the osteology of the Ichthyosaurus; from the observations of H. T. de la Beche, Esq. F.R.S., M.G.S., and the Rev. W. D. Conybeare, F.R.S., M.G.S. (Read April 6th, 1821.) Drawn up and communicated by the latter." The observations on the vertebral characters of the new reptile are said to have been made "on the organic remains contained in the Lias in the vicinity of Bristol" (p. 559). 'Transactions of the Geological Society of London,' first series, vol. v.

some vertebræ a low and narrow ridge extends from the neur- to the pleur-apophysial surfaces, as at *c*, fig. 4.

The degree of concavity of the sides of the centrum in the anterior cervicals, exposed in the specimen figured in Tab. III, fig. 1, has been exaggerated by the pressure to which it has been subject, the effects of which are more conspicuous upon the skull: the cancellous mid-part of the centrum has opposed less resistance than the compact articular ends.

The atlas (*a*) has been disarticulated from the occipital condyle (1); the hemispheric articular cup is thus well displayed, with its smooth and shining surface. The coalescence of the centrums of the atlas (*a*) and axis (*x*) is complete. A tubercle from the side of the centrum of the atlas represents the pleurapophysis; its neural arch is broken away; that of the axis developes a spine similar to and but little smaller than that of the third cervical.

The dimensions of the seven vertebræ here preserved in connection with the skull will be seen in Tab. III, fig. 1, where they are figured of the natural size. The average dimensions of a cervical centrum of the present species, from the middle and basal half of the neck, are, as in figs. 4, 5, 6—

	In.	lines.
Length	1	4
Breadth of articular surface	1	6
Height of middle of ditto	1	3
Length of costal pit	0	6
Transverse diameter of outlet of neural canal	0	6

Dorsal series.—The transition from the cervical (Tab. I, C) to the dorsal series (ib., D) is effected by the usual elevation of the costal surface by gradational steps, continued through about five vertebræ, until a single costal surface is presented by a large diapophysis from the neural arch. The number of cervical vertebræ so defined in the specimen figured in Tab. I is forty-one. In the first dorsal, characterised by the diapophysial support of the rib (Tab. IV, figs. 1 and 2, *d*), the non-articular part of the centrum is smoother than in the cervical vertebræ, the ridges or rugæ occupying a smaller extent near the two ends, where they indicate the attachments of the capsular ligaments. The longitudinal concavity between the two ends is uniform and rather more than in the cervicals. The venous foramina are wider apart and not divided by any special transverse convexity on the under surface of the centrum. A vertical ridge leads from the side of the centrum (ib., *c*) to the under part of the diapophysis (ib., *d*), nearer the hind than the fore end of the centrum.

The diapophysis is convex and longest superiorly; the fore part is rather hollowed, the hind part flattened, and both converge to the ridge forming the shorter under surface. The articular surface (^{d}) of an irregular oval form, with the small end down-

ward, looks downward, outward, and a little backward, the process being slightly inclined that way. The margin of the articular end of the centrum is better defined than in the neck; about a line's breadth is, as it were, shaved off; the rest of the surface (fig. 2, *c*) is very slightly concave, sometimes undulated, always nearly flat, and with a small central depression, or a tendency there to a tubercle. The length of the dorsal region in the skeleton (Tab. I) 8 feet 9 inches long, is 2 feet 6 inches; the number of dorsal vertebræ is twenty-one.

Sacrum.—Two vertebræ (ib., *s*) succeeding the dorsals are distinguishable, through the greater thickness and straightness of their short pleurapophyses, as sacral; these elements abut against, or afford ligamentous union to, the iliac bones.

Caudal series.—The caudal vertebræ (Tab. I, C *d*, Tab. IV, figs. 3—9) are shorter in proportion to their breadth than the others; the centrum approaches to a cubical figure, the under surface (figs. 4 and 7) becoming broad and flattened; and the contour of the terminal articular surfaces shows a similar tendency to flattening, giving a transversely extended quadrate figure, with the angles rounded off (figs. 5 and 8); the margin is thicker, more rounded off, less defined than in the dorsal vertebræ. The articular surface itself is more concave than in the antecedent regions of the backbone, and becomes deeper in the terminal subcompressed vertebræ (fig. 9); the movements of the tail in swimming having been helped here by a greater amount of yielding intervertebral substance, approaching in the same degree to the condition of the spine in fishes. The costal surface (figs. 3, 6, *pl*) is elliptic, with the long axis subvertical, the margin prominent, the cavity simple and rough for the ligamentous attachment of the riblet; it is situated on the upper half of the centrum close to the neurapophysis, the outer end of the base of which contributes to the upper part of the margin in the anterior caudals (fig. 5, *d*).

The pleurapophyses in this region (Tab. IV, 5, *pl*) do not expand terminally, as in the neck; they are short, thick, and straight, simulating transverse processes; their non-confluence with the centrum exemplifies the minor vigour of vital co-ossifying influences in terminal parts.

The hæmapophysial surfaces (fig. 3 *h'*) impress the inferior angles of the posterior surface of the centrum; occasionally, where a hæmapophysis has become anchylosed and broken off, its adherent base gives the appearance of a process from that part of the centrum (ib., figs. 6, 7, 8, *h'*). The venous foramina are at the lower part of the sides of the centrum. The neural arch (figs. 3, 5, *n*) rapidly diminishes in size and in the length of the neural spine, *ns*. The zygapophysial surfaces become more vertical, the anterior, *z*, looking inward; the posterior zygapophyses, *z'*, are the first to disappear. The hæmapophyses (fig. 5, *h*) are free, and were ligamentously connected with the centrum above and with each other below, circumscribing there the hæmal canal. The proximal surface is expanded, with a subtriangular facet cut obliquely at the anterior part for articulation with its own surface, and with a smaller, less definite

surface posteriorly for the intervertebral substance and a small part of the succeeding centrum, where a slight expansion of the everted border of the articular surface is the sole indication of such hæmapophysial junction. In the terminal vertebræ these surfaces with the hæmapophyses have disappeared, and the centrum, now showing a compressed form, supports only a contracted, anchylosed, seemingly exogenous neural arch, which finally disappears.

The following are transverse diameters of the centrum in different regions of the spine, in the specimen, 8 feet 9 inches long, of *Plesiosaurus dolichodeirus*, figured in Tab. I:

	In.	lines.
Tenth cervical vertebra	1	0
Middle dorsal ditto	2	0
Tenth caudal ditto	1	3

Cranial characters (Tabs. II and III).

The skull in this skeleton presents, what is rare, the side or profile view (Tab. II) like that of the succeeding anterior cervicals. Its upper part is much injured. The following bones are recognisable:—mastoid 8, tympanic 28, squamosal 27, malar 26, maxillary 21, premaxillary 22; the end of the long pterygoid is seen at 24, abutting against the lower end of the tympanic. But little of the composition of the mandible is discernible; the tightly closed jaws show the extent of the interlocking of the long, slender, curved, and sharp-pointed teeth.

Of those of the lower jaw the crowns of upwards of twenty may be traced; the longest occupying the middle three fourths of the series, and the largest of these being the foremost. In some parts of the series two teeth pass into the same dental interspace of the opposite jaw.

The admirably wrought-out specimen figured in Tab. III, fig. 1, exhibits the upper surface of the somewhat crushed skull. Of the basi-occipital a part of the upper surface (1) and of the single median convex condyle is shown. The exoccipitals (ib., 2) preserve their connection with the lateral and upper parts of the basi-occipital, and show the surfaces—seemingly sutural—from which the superoccipital (ib., 3) has been displaced. These surfaces (2, 2) are thick and triangular; they are parallel with the middle of the foramen magnum, the lower half of which is formed by the basi- and ex-occipitals. From the outer and back part of the exoccipital the paroccipital process (4, 4) is continued; of subtriedral form, long, slender, and tapering to a thin rounded apex: the outer side appears to be sutural, and that of the left side is applied to the tympanic (ib., 28): the length of this process is 8 lines. The breadth of the occiput, outside of the exoccipitals, is 1 inch 5 lines; that of the foramen magnum is 6 lines. That the rough triangular upper surfaces of the exoccipitals are natural, not the result of frac-

ture, I infer from their being on the same level, and from the corresponding surfaces being presented by the single arched bone (3) representing the superoccipital. This has been displaced by the pressure operating not quite vertically, but with an inclination from the left to the right, which has turned the spines of the cervical vertebræ to the right, and which has so far displaced the superoccipital in the same direction that it lies with its concavity or arch embracing, as it were, the right superoccipital, this concavity having formed the upper half of the foramen magnum. The apex of the superoccipital lies beneath the right branch of the parietal; the outer surface of the piers of the superoccipital arch is moderately smooth and convex; the breadth of the base of the arch is 1 inch 3 lines, that of the span of the arch is 5 lines.

The parietal (ib., 7) is thick and transversely extended posteriorly, where it is overlapped by the mastoids (8), anterior to which it contracts to form the crest between the temporal fossæ. The crest is interrupted by the parietal foramen (*f*), anterior to which it is resumed for a short extent—3 lines, before the frontal suture. The total length of the parietal is 1 inch 11 lines; the length of the crest is 1 inch 3 lines. The thick and rather rugged hinder bifurcate part of the parietal is overlapped or embraced by the mastoid (8), and these bones curve outward and backward to articulate with the squamosal (27) and with the tympanic (28), which is continued in the same direction to the joint of the mandible (29). All these bones together form a strong arch, curved backward in the present specimen, but owing its horizontal position to the posthumous pressure, and having the piers of the arch directed downward as well as outward and backward in the natural state.

The suture between the frontals (11) remains, and that between the postfrontals (12) and the expansions of the parietal (7′) upon the sides of the cranium may be traced. There is a smooth superorbital (11′) between the rougher frontal and the orbit, unless the fissure defining them be a fracture and not a suture. The external facial plate of the prefrontals is rough; it overlaps the fore part of the frontal and part of the nasal, and extends to the small external nostril. The nasals (15) overlap the fore part of the frontals, and extend about as far in advance of the nostrils as they do behind them, continuing the median ridge from the frontals forward, in which, however, the median suture is visible. The outer surface of the maxillaries and premaxillaries shows a kind of granular rugosity, which subsides in the maxillary as this bone (21) extends beneath the orbit. The limits of the lacrymal (73) are not definable. The malar (26) forms the hinder half of the suborbital boundary; its surface is smooth, and increases in breadth to beyond the orbit, when it contracts and becomes rugous where it joins the postfrontal (12) and squamosal (27). The bony boundary between the orbital and temporal cavities is crushed and much cracked: but the outer end of a postfrontal or postorbital is wedged into the squamous union of the malar and squamosal. The latter (27), of a tri-radiate form, curves from the malar round the outer and back angle of the temporal fossa, and extends backward upon the tympanic: the ray directed

mesiad, and overlapping the mastoid (8) and tympanic (28), is the longest, and terminates in a point: the surface of the bone is smooth.

The temporal fossæ are broader than they are long. At their forepart the parietal side-wall of the cranium expands as it advances, and is continued into the postfrontal or postorbital partition.

The orbits are rounded anteriorly, and both the upper and under parts of the frame make an angular junction with the straight hinder part.

The nostrils have the usual small size and backward position.

In both orbits some of the thin sclerotic plates of the eyeball (*s*, *s*) are preserved; this is the first specimen in which I have had evidence of this structure.

The interlocking of the teeth of the upper and lower jaws, through the singular care and skill devoted by Mr. Harrison to the removal of the matrix, is peculiarly well displayed in this instructive fossil.

The foremost tooth in each premaxillary make a pair, which curve forward and downward between the two foremost teeth of the lower jaw, the premaxillary teeth slightly diverging as they descend, Tab. III, fig. 3. The succeeding premaxillary teeth, four in number, alternate with mandibular ones. I cannot make out with certainty the maxillo-premaxillary suture, but the fifth tooth, counting backward, seems to be near to or upon it. The second premaxillary tooth is double the size of the first; the third, fourth, and fifth gradually diminish; the sixth (first maxillary ?) is small; the seventh tooth suddenly resumes the size of the second; and the eighth, of nearly equal size, curves down close to the seventh, and the two are interposed between the interspace of opposite mandibular teeth. From four to five smaller teeth are traceable behind the eighth, and there may have been more in the upper jaw.

Of the lower jaw ten teeth are shown on each side; the second, third, fourth, and fifth are the longest and largest, as in Tab. II. In general, the teeth of the upper jaw are separated by intervals allowing the passage of those of the lower; the teeth of the foremost premaxillary pair being closer together; and those of the foremost mandibular pair being wider apart. They all present the usual generic character of crown—long, slender, curved, pointed, circular in transverse section, with the enamel finely but definitely ridged longitudinally. The longest exserted crown measures ten lines, the shortest four lines, the thickness being in proportion.

The true number of the teeth in the lower jaw is yielded by the specimen of the dentary bone, Tab. III, fig. 2, in which twenty-five alveoli are shown on one side, and twenty-four on the other. The size of the alveoli, and the extent of their interspaces, are greatest at the anterior half of dentary. The small successional teeth at the posterior part of the series are so advanced as to look like a double row at that part. A longitudinal groove or depression at the inner side of the base of the alveoli lodged the thicker mass of the vascular gum overlying the matrices of the successional teeth.

The skull of the *Plesiosaurus dolichodeirus* is broad in proportion to its length, with

a broad and short muzzle, of an equilateral triangular figure if the transverse lines across the fore part of the orbits be taken as the base, the two sides converging to the rounded apex in almost straight lines, with a feeble indication of a constriction where the maxillo-premaxillary suture seems to be. The contour is undulated by the expansions for the sockets of the larger teeth, which produce risings, with intervening furrows on the granulate alveolar borders of the jaws. The mandibular rami converge to their terminations at the symphysis, which is not prolonged or expanded.

The specimen (Tab. III, fig. 1) from the Lias of Charmouth was wrought out of its matrix by the estimable discoverer of the Liassic Dinosaur (*Scelidosaurus*) described in a former Monograph. It is an admirable example of patience, pains, and skill; in the bestowal of which, for the furtherance of science, upon the fossils roughly wrought out of the quarries in his neighbourhood, Mr. Harrison found solace during the long and trying illness which confined him to his bed, until his final release by death.

Pectoral and pelvic limbs (Tab. I, figs. 2, 3).

To complete the characters of *Plesiosaurus dolichodeirus* I have reproduced, in outline, the bones of the pectoral, fig. 2, and pelvic, fig. 3, limbs, as they are preserved in the type-specimen. The humerus, 53, shows rather more convexity at the anterior border, and a deeper concavity at the posterior border than in some other species (*Plesiosaurus Hawkinsii*, *Pl. macrocephalus*,* *Pl. rugosus*, e. g.). The radius, 54, and ulna, 55, are of equal length; the ulna not being shorter than the radius, as in *Pl. Hawkinsii* (Tab. XIV, fig. 6); the ulna has not the olecranal process or epiphysis, as in the *Pl. rugosus* (Tab. XIV, fig. 2, 55′); and both antibrachial bones are less broad, in proportion to their length, than in the *Pl. macrocephalus* † (Tab. XIV, fig. 4). The carpus shows seven bones, four in the proximal, three in the distal row; their homologies will be pointed out in the description of *Plesiosaurus rugosus*. The metacarpal of the first digit (Tab. I, fig. 2, i), answering to "pollex," supports at least three phalanges; that of the fifth digit, seven phalanges; the metacarpal of each of the others, six phalanges, but the terminal ones may be wanting in some. The pelvic fin (fig. 3) is rather longer than the pectoral one; in both fins the fifth digit (v) articulates on a more proximal plane than the others, *i. e.* nearer the trunk, as in most other *Plesiosauri*. In the same skeleton the pectoral limb equals seventeen of the middle cervical vertebræ in length; ‡ in *Pl. macrocephalus* it equals sixteen of these vertebræ, in *Pl. rugosus* it equals fifteen.

* 'Geological Transactions,' 2nd series, vol. v, pl. 43.

† Ib.

‡ The artist has drawn the outline of the limb-bones, figs. 2 and 3, on a larger scale than that of the skeleton, in Tab. I.

Plesiosaurus homalospondylus (Tabs. V—VIII).

In the year 1842 I examined, in the Museum at Whitby, Yorkshire, a collection of Plesiosaurian vertebræ, which had been taken out of a heap of rubbish from the old alum works carried on in the upper Alum Shale—a part of the Liassic series on that coast, characterised by the *Ammonites heterophyllus*, Sow.

The vertebræ were divisible into two groups, indicative of two species of *Plesiosaurus*.

Of one kind there was a series of sixteen consecutive cervical vertebræ, characterised by the unusual concavity of the terminal articular surfaces of the centrum. On making a section of two of these vertebræ cemented by the matrix in their natural state of co-adaptation, the margins of the opposed articular surfaces were two lines apart, showing the thickness of the inter-articular connecting ligamentous substance at that part, while the middle of the articular surfaces left an interval of eleven lines, thus approaching the ichthyosaurian type of vertebral union.

The following were dimensions of the centrum of these cervicals.

	In.	lines.
Length	1	9
Breadth of articular surfaces	1	11
Height of ditto	1	10

The inferior surface of the centrum showed a median longitudinal convex ridge between the two wide elliptical venous foramina. I named the species indicated by these vertebræ *Plesiosaurus cœlospondylus*,* in reference to the hollow terminal articular surfaces. I hope to have, at a future opportunity, further means of illustrating this species.

The second series of vertebræ presented almost flat articular surfaces of the centrum (Tab. V, figs. 3 and 6); the inferior surface was devoid of a median ridge, or had only a slight rising (fig. 4, *v*) between the venous foramina, which were smaller and more narrowly elliptical (ib., figs. 4 and 7) than in *Pl. cœlospondylus*; the middle of the surface was bounded laterally by the costal surfaces (ib., *pl*), and was nearly flattened, being very slightly concave, both lengthwise and transversely. The costal surface is of a narrow elliptical form, with the long axis parallel with that of the centrum; the dividing line or fissure is not conspicuous; it is situated, as usual, rather nearer the back than the front end of the centrum (Tab. V, fig. 2, *pl*); and a space more than twice its vertical diameter intervenes between it and the neurapophysis (ib., *np*), or

* Κοῖλος, hollow, σπόνδυλος, vertebra.

neurapophysial surface. A low, longitudinal rising, or obtuse ridge, traverses the free surface of the side of the centrum midway between the pleur- and neur-apophysial articular surfaces.

The following were dimensions of the centrum of a cervical vertebræ answering, or nearly so, in position, to that of the *Plesiosaurus cœlospondylus* selected for measurement—

	In.	lines.
Length	2	0
Breadth of the articular surface	1	10
Height of ditto	1	6

These dimensions showed the greater proportional length of the cervicals of the present species; and, concurring with the more obvious difference in this shape of the terminal articular surfaces, I thereupon devised the name of *Plesiosaurus homalospondylus*,* indicative of the even or level character of those surfaces, for the species so characterised.

I have subsequently received several additional vertebral evidences of both these species of the Upper Lias, or Alum Shale of Whitby, and, finally, have had the opportunity of studying two almost entire skeletons of the *Plesiosaurus homalospondylus* from that locality, one of which (Tab. VIII) is now in the Museum of the Philosophical Society of York, and the other (Tab. V) has been purchased by the Trustees of the British Museum, where it is now exhibited in the Geological Department. Both of these specimens exhibit the striking character of the genus Plesiosaurus in a maximised degree, viz., in the length of the neck and the smallness of the head.

I propose, first, to describe the specimen in the British Museum, Tab. V.

This specimen gives indications of the same conditions of interment in its matrix, and of the operation of subsequent gradual pressure, as that of the species last described, from the lias of another part of the kingdom.

It has sunk into the mud, which afterwards became petrified, either prone or supine; for I have been unable to obtain evidence as to whether the present exposed part of the skeleton was wrought out from the upper or under surface of the block, as removed from the quarry; but we may assume the former, and consider that the animal was originally imbedded with the upper or dorsal surface toward the observer. Both fore and hind paddles were outstretched at right angles with the axis of the trunk, but only their proximal bones or segments have been preserved. The skull and cervical vertebræ have maintained their original position. At the base of the neck, where the neural spines, from their height and breadth, began to afford a surface upon which the dislocating force could operate, they have begun to yield toward the left

* Ὁμαλός, planus; σπόνδυλος, vertebra.

side, and, in the dorsal region, D 1 — 60, are turned flat in that direction. At the base of the tail, where these flattened surfaces again become diminished in extent, the vertebræ gradually resume their vertical or prone position, the summits of the spines being uppermost, as far as the seventieth (counting from the head), beyond which some dozen of the terminal caudals are jumbled together in an irregular group, as if that part of the carcass, supporting perhaps a caudal expanse of integument or fin, had been subject to some disturbing influence prior to complete imbedding in the matrix.

I conclude that this partial rotation of the dorsal series took place before the petrifaction of the bones and bed; because the ribs of the right side have slipped from their attachments to the diapophyses, in a degree corresponding with the extent of the rotation. For, had they been cemented in their natural connections by the Lias stone, *i. e.*, after the petrifaction of the mud, and prior to the operation of the extraneous pressure, they might have been expected to have been bent or broken, when pressed into the same plane with the neural spines, without any slipping from their previous joints; whereas this dislocation implies a rotting away of the articular ligaments, and a certain yielding of the surrounding bed.

The chief characteristics of the skeleton of the *Plesiosaurus homalospondylus* are, the length of the neck, the height and breadth of the dorsal and contiguous cervical and caudal spines, with the smallness of the head. The length of the neck is due both to the number of vertebræ—thirty-eight, and to their proportionate length individually, and chiefly to the latter character, as compared with *Plesiosaurus dolichodeirus* (Tab. I).

I caused to be carefully removed from the matrix of the present skeleton the thirteenth and fourteenth (Tab. V, figs. 2—4) of these instructive vertebræ, the length of the centrum in which agreed with that on which I had made notes and drawings in 1842. They corresponded in every other particular with these vertebræ. The low, longitudinal ridge or rising (Tab. V, figs. 2, 5, *r*) on the side of the centrum may be traced throughout the neck. Fig. 7, Tab. V, gives a view of the under surface of the eighth cervical vertebra; fig. 6 gives an end view, and fig. 5 a side view of the centrum of the third cervical vertebra, all of the natural size. The specific characters are well exemplified in these, which may be profitably compared with the figures of the corresponding vertebræ of the *Plesiosaurus planus*, in a former Volume,* as exemplifying the degree in which vertebral characters are developed in the different species of the genus.

The cervical ribs, as indicated by the articular surface (Tab. V, figs. 2, 7, *pl*), are of small size in proportion to the rest of the vertebra, until about the thirtieth, in which the transverse outstanding part of the stem is two inches three lines in length, and the longitudinal part two inches six lines. In the thirty-fourth vertebra this has attained

* Volume I, 'British Fossil Reptiles;' Supplement No. II to the 'Fossil Reptilia of the Cretaceous Formations.'

a length of four inches; the production, anterior to the transverse stem, being nearly an inch in length. In the thirty-fifth vertebra (Tab. VII, C 35) the costal surface projects, the rib begins to ascend, the anterior production to shorten, the posterior one to lengthen. In the thirty-seventh (ib., 37) the rib is supported in equal proportions by the centrum and by a diapophysial growth of the neurapophysis. In the thirty-eighth (C, 38) the rib has passed almost wholly upon the diapophysis, and has assumed a simple rib-like character, slightly bent, with a length of six inches. In the thirty-ninth vertebra (ib., D 1) the transit from centrum to neurapophysis, *np*, is complete, denoting the first of the dorsal series. In the second dorsal vertebra of the present skeleton the rib has slipped forward from its joint, *d*. In the forty-third (Tab. V, fig. 1) it is depressed an inch below the diapophysis. In the forty-sixth to the fiftieth vertebræ the heads of the ribs lie beneath the centrums, and the side view of the whole of those vertebræ is obtained. In the succeeding dorsals the ribs gradually approximate their suspending processes, and have resumed their articulation at the twentieth dorsal, or the fifty-eighth vertebra, counting from the atlas.

The ribs of the forty-seventh to the fifty-first vertebræ are from sixteen to seventeen inches in length; they are the longest of the series. The articular head presents a diameter of one inch and a half; the anterior surface is convex transversely; the outer part of the posterior surface is rather concave in the same direction, so that the outer margin of the proximal half of the rib, to near its head, presents the character of an obtuse rim or ridge. They gradually decrease in size as the vertebræ recede in position from the fiftieth; and, at the sixtieth, are reduced to a length of four inches: this and the two succeeding ribs seem to have become anchylosed to the diapophyses. In the sixty-second vertebræ the rib suddenly augments in thickness, extends its articulation downward upon the centrum, and represents a sacral vertebra (Tab. I, s). That of the sixty-first vertebra is somewhat less thick, but it may have assisted in affording attachments to the ilium (ib., 62), the proximal end of which bone is in contiguity with the converging terminations of the ribs of the sixty-first and sixty-second vertebræ. The anchylosed condition, with shortening of the caudal ribs, or pleurapophyses, give them the usual character of transverse processes in the caudal region.

The neural spines, thin and antero-posteriorly extended in the neck (Tab. V, fig. 2, *a*, 2, *ns*), have been more or less broken away, in the operation of exposing the specimen, from the anterior three fourths of the vertebræ in that region. Their height gradually decreased as they approached the head and receded from that of the thirtieth vertebra (ib., 30), which rises four inches from the summit to the neural arch, having a fore-and-aft diameter of two inches three lines, and a thickness of three lines. The former diameter is least a little above the origin of the spine, and gradually increases toward the summit, where the spines are in contact. In the thirty-third vertebra the neural spine is five inches in length, and its breadth of two inches three

lines is maintained through nearly the whole of that length, in corresponding close contact with the contiguous spines. In the thirty-seventh vertebra (Tab. VII, 37) the length of the neural spine is five and a half inches; it has a little increased in thickness; the fore-and-aft diameter continues the same. In the second dorsal the neural spine is six inches four lines in length, with a thickness of six lines. These dimensions are continued to the fifty-eighth vertebra, save that, in the posterior half of the dorsal series, the spines have less fore-and-aft breadth at their proximal third, and leave correspondingly wider intervals; they are in contact at their more expanded distal portions. From the fifty-eighth vertebra they gradually decrease in length to the sixty-second, or sacral vertebra, showing a height of less than four inches, with a terminal fore-and-aft extent of two inches, and a thickness of six lines. They decrease in all dimensions as the caudals recede from the trunk, and most so in fore-and-aft extent, leaving wider interspaces; by which character, with the higher position on the centrum, and anchylosed condition of the pleurapophyses, a caudal vertebra may be distinguished from a cervical of similar size. The caudal centrums are also thicker in proportion to their length, and the under surface, if exposed, would doubtless also yield the character of the hæmapophysial pits.

The dorsal diapophyses progressively increase from the first (Tab. VII, D 1, 2, *d*), and attain, at the fifth dorsal vertebra (Tab. V, fig. 1), a length of two inches three lines along the upper border. The rib-surface is cut from above downward and inward, shortening the under extent of the process. A low ridge is continued from the posterior angle of the neurapophysis upon the back part of the diapophysis, which expands to the truncate articular surface. After the sixteenth dorsal the diapophyses gradually shorten to the sacral vertebræ, where they have almost subsided.

The zygapophyses in the neck (Tab. V, fig. 2, *z*, *z'*) and greater part of the back are nearly horizontal, the anterior ones looking a little inward as well as upward, the posterior ones the reverse; they are given off nearer the base of the neurapophysis than usual (compare Tab. V, fig. 2, *z*, *z'* with Tab. III, fig. 4, *Plesiosaurus dolichodeirus*, and Tab. X, fig. 1, *Pl. rostratus*), towards the end of the back their aspect gradually changes; and, in the tail, the articular surface becomes almost vertical; that of the anterior ones, which are most developed and longest retained in the vertebral series, looking inward. The terminal articular surfaces of the centrum of the last dislocated caudal vertebræ are, as usual, more concave than in the neck.

The development of the neural spines throughout the trunk and base of the neck is such as to impede inflection in the vertical direction. At the anterior half of the long and slender neck this bend would, indeed, take place in some degree; but the greatest flexibility would be from side to side. The provision for the attachment of the vertebral muscles in the trunk is very great, indicative of corresponding power of regulating the movements and position of the body during the application of the

lengthened, slender neck, and small head, in the capture of fishes or other active marine prey.

The whole framework of the trunk is singularly massive, and the character of this part of the skeleton, as shown in the specimen (Tab. V), is especially striking in contrast with the slender neck and small head of the animal.

Of the Skull (Tab. VI).

The skull (Tab. VI), from the occiput to the end of the snout, is 9 inches long; it measures 4 inches 4 lines across the middle of the temporal depressions, 3 inches 6 lines across the occiput, which rises but 1 inch in height above the foramen magnum; the intertemporal part, or parieto-frontal crest, rises into a sharp ridge; the length of the temporal fossa is 2 inches 9 lines, the breadth is 2 inches. The diameter of the orbit is 1 inch 6 lines; from the fore-part of the orbit to that of the snout is 4 inches. The elliptical nostril shows a long diameter of about 6 lines, it is situated about 8 lines in advance of the orbit, and about the same distance from its fellow. The inter-narial portions of the nasal and premaxillary bones rise into an obtuse ridge. The teeth are small, slender, slightly recurved at the fore-part of the jaw, where the enamelled crown of the longest does not exceed 10 lines. No sutural evidence of cranial structure is discernible; the bones about and between the orbits show the effects of pressure. Estimating the length of the skull by that of the lower jaw, about two inches should be added to that taken from its exposed and visible part.

This part of the skull (Tab. V) is susceptible of satisfactory comparison with the corresponding region of the skull in the *Plesiosaurus dolichodeirus* (Tab. III, fig. 1), the species which most resembles the *Plesiosaurus homalospondylus* in the length of the neck and the small proportional size of the head.

By comparing Tab. III with Tab. VI, in which the skulls of the two species are figured of the natural size, from probably mature individuals of average size, and from the same aspect, the difference of proportion and form is such, and so obvious, that, were two skulls of existing lizards to be so contrasted, it is probable that some Erpetologists would be led to sever them more widely than by specific bounds. The composition of the cranium, the position and relative size of its principal cavities, and especially of the nostrils, the character of the dentition, are, however, so strictly Plesiosaurian in the two fossil skulls here compared, that there is no sufficient ground for encumbering the Sauropterygian group with one or two additional generic names.

The skull of *Plesiosaurus homalospondylus* is longer in proportion to its breadth, more oblong in shape, more obtusely terminated anteriorly. It is possible that the skull of the *Plesiosaurus dolichodeirus* compared (Tab. III) may have suffered more horizontal pressure, but not such as to have affected its triangular shape due to the

more rapid convergence of the sides of the upper jaw to the more pointed muzzle. The temporal fossæ may appear broader than natural in this crushed skull, but with due allowance this shape was square, not oblong, as in *Plesiosaurus homalospondylus.* The intervening parieto-frontal crest is relatively longer, and we may infer that the biting muscles were larger and more powerful in relation to the more massive proportions of the dentigerous parts of the jaws in *Plesiosaurus homalospondylus:* the orbits are relatively less; their antero-posterior diameter is less than one fifth of the same diameter of the skull taken from the back part of the parietal (7) in *Pl. homalospondylus;* it is more than one fifth in *Pl. dolichodeirus;* the orbits are equidistant from the two extremes of this diameter in *Pl. homalospondylus;* they are nearer the back part of the head in *Pl. dolichodeirus.* In *Pl. rostratus* (Tab. IX) the temporal fossæ present somewhat intermediate proportions between those in the two foregoing species; but the rostral production of the maxillary part of the skull sufficiently distinguishes the cranium of *Pl. rostratus* from that of previously known species in a comparison of detached skulls; whilst its greater relative size to the body more especially distinguishes it from that in *Pl. homalospondylus* or *Pl. dolichodeirus.*

In *Pl. Hawkinsii* * the longitudinal diameter of the temporal fossa exceeds the transverse diameter, but not in so great a degree as *Pl. homalospondylus,* and the upper jaw is relatively narrower than in that species. This is also the case in *Pl. macrocephalus,*† in which there is a more marked constriction of that part, anterior to the orbits, showing a tendency to the "rostral" character, which is exaggerated in *Pl. rostratus.*

Pectoral and pelvic arches and limbs (Tabs. V and VIII).

Of the limbs only the humeri and femora have been preserved in the skeleton (Tab. V); these bones show the usual form, with their respective characteristic modifications, as exemplified in the different contour of the anterior border, which is straight or partly convex in the humerus, and is concave in the femur. The length of the humerus is 12 inches, that of the femur 13 inches; the distal breadth is nearly the same in both, namely, 6 inches. In the right femur, the coarse fibrous texture which pervades the whole thickness of the bone is exposed. A portion of the extensive scapulo-coracoid arch comes into view from beneath the anterior dorsals on the right side (Tab. V, 52). The ilium (ib., 62) presents the usual form; straight, slender at its proximate end, with a slightly twisted, subcylindrical shaft, expanding to a breadth of nearly three inches at its acetabular end. The entire length of the

* 'Geol. Trans.,' 2nd series, vol. v, pl. 45.

† Ibid.

skeleton (Tab. V) is fourteen feet, which would be increased by several inches were the tail entire and outstretched.

The specimen of *Pl. homalospondylus* in the Museum of the Yorkshire Philosophical Society is larger than the one in the British Museum, but has been lithographed on a smaller scale in Tab. VIII; it measures 16 feet 6 inches in total length. It lies in a somewhat similar posture to that in the British Museum, but with the long and slender neck and anterior dorsals bent so as to give a concavity to the dorsal contour of the animal; the caudal vertebræ, which are better preserved, are also bent in the same direction, and all the vertebræ follow in their consecutive undisturbed juxta-position in both skeletons. The numbers of the vertebræ in the cervical and dorsal series respectively appear to be the same. The diapophysis has got entire possession of the rib at the fortieth vertebra, counting from the head; and the costal surface begins, with its process, to sink again upon the centrum, at the sixty-seventh vertebra, which the thickness of the diapophysis indicates to be a sacral vertebra. Beyond this may be counted twenty-seven caudal vertebræ, and it is not probable that their number exceeded thirty.

The cervical vertebræ show the same distinctive characters of the species which have been already defined; the neural spine is preserved in a much greater proportion of the cervical series; in the fifteenth cervical it shows a height of two inches, and a nearly equal antero-posterior breadth; with a broadly truncate summit, having the angles rounded off. The vertebræ keep their proportion of length from this point to the end of the dorsal series; they then grow shorter to the end of the tail, throughout the greater part of which the centrum is deeper, and the neural spines longer and narrower, than in the neck, indicative of the greater mass of muscle operating on the tail, and also its greater flexibility in a given extent. The costal series has suffered much more displacement and loss in the York specimen than that in the British Museum; the larger ribs are a good deal jumbled and broken in the region of the trunk or thoracic abdominal cavity, but they show the same massive character. The ischio-pubic part of the pelvis has been drawn away, at an acute angle, from the ilium and sacrum; its inner or upper surface is exposed at 63, 64, Tab. VIII. The right pelvic limb has been moved forward, with the head of the femur lying upon the lower end of the right coracoid. The right pectoral limb extends forward from near its normal place of articulation with the coracoid; but it has been turned bodily over, showing its inner or palmar surface. The limbs of the left side are huddled in a dislocated and incomplete state beneath the hinder part of the trunk.

The presence of both these limbs, in an excellent state of preservation, supplies the chief deficiency in the specimen in the British Museum previously described.

The pectoral limb, as in *Pl. dolichodeirus*, is rather shorter than the pelvic one; its entire length is 3 feet 8 inches, equalling sixteen vertebræ towards the base of the neck. The humerus, 13 inches in length and 7½ inches in distal breadth, is broader

there, in proportion to its length, than in the *Pl. dolichodeirus* or than in the *Pl. rostratus;* its anterior margin, as in the skeleton Tab. V, is more straight than in those species. The antibrachial bones (54, 55) show intermediate proportions of length and breadth between those in *Pl. dolichodeirus* (Tab. I, fig. 2) and *Pl. rostratus* (Tab. IX). They present the usual characteristics of radius (54) and ulna (55) in the present genus, and they are of equal length. The hand measures two feet in length, and is somewhat longer in proportion to the arm and forearm than in the two above-cited species; it also shows rather more breadth. The carpus consists of six bones, three in each row, and with less inequality of size. The distal bones occupy an equal breadth with those of the proximal row, and do not allow the base of the fifth metacarpal to extend backward to the proximal row, as in the species of which the carpus is figured in Tab. XIV. The bases of the five metacarpals (in Tab. VIII, 57) are on the same transverse line; and if this specimen should truly exhibit the relative position of the bones of the pectoral fin, characteristic of the species, it adds a well-marked distinction of the *Pl. homalospondylus.* The first, or radial, or innermost metacarpal (57), supports a short digit of three phalanges; the second a digit of seven phalanges; the third the same; the fourth has a digit of six phalanges; the fifth is obviously imperfect.

The pelvic limb (Tab. VIII, 65, 69) is 3 feet 9 inches in length; the femur (65) is 14 inches long and $7\frac{1}{2}$ inches across the distal end. The tibia and fibula are respectively longer than their homotypes the radius and ulna; the foot is 2 feet in length and $7\frac{1}{2}$ inches in basal breadth. The tarsal bones are similar in number and arrangement to those of the carpus; and as the bases of the five metatarsals (69) are in this limb also on the same transverse line, I have the greater confidence in the natural structure being here shown in both limbs, and that they thus exhibit a distinctive character, of specific value, from the other Plesiosauri described in the present Monograph.

Plesiosaurus rostratus, *Owen.* Tabs. IX—XIII.

The specimen on which this species is founded was obtained, in 1863, by Edward C. Hartsinck Day, Esq., F.G.S., from the Lower Lias at Charmouth, Dorsetshire, by whom it was transmitted to London for inspection, and it has been purchased by the Trustees of the British Museum, where it is now exposed in the gallery of Geology. It is figured, one ninth of the natural size, in Tab. IX.

This skeleton, like most of the plesiosaurian ones that have come under my observation, indicates the ordinary and tranquil character of the death and burial of the individual; it has sunk entire, relaxed, and prone, with outstretched limbs, in its matrix, when this was soft and yielding; and, as decomposition loosened the liga-

mentous attachments of the vertebræ and of their elements, they have yielded to external pressure or movement of the matrix, and have rotated on their axis—some of the long-spined vertebræ to the right, some to the left—with a slight displacement of the longer ribs from their attachments.

The third cervical vertebra is displaced about three inches below the axis and atlas, which remain in connection with the occipital tubercles, the third to the fifteenth cervicals are prone with the spines uppermost, and the pleurapophyses in natural connection with the sides of the centrum, the lower part of which is buried in the matrix. Except a slight dislocation between the seventh and eighth, these cervicals have retained their natural sequence and relative position. As the spines grew longer and larger they offered a surface upon which the superincumbent pressure could operate, so as to rotate the vertebræ sideways; and from the sixteenth to the twenty-eighth inclusive, they are turned half round, with the spines downward or to the left; but all these vertebræ retain their natural mutual connections. The twenty-ninth vertebra is dislocated, exposing the anterior articular surface of the centrum; the thirtieth has suffered fracture of its spine; the thirty-first and thirty-second are partly bent to the left; the thirty-third and thirty-fourth are turned with the spines to the right side; that of the thirty-fifth is broken from its neural arch; the thirty-sixth to the forty-eighth vertebræ have the neural spines turned to the right, retaining almost their natural relative positions. The forty-ninth vertebra has kept the original prone position, as when imbedded; the next ten show the side view, with the neural spines to the right; the sixty-first to the sixty-fifth are prone, but with a slight deviation of the neural spines, some to the right, some to the left; the next six vertebræ have yielded in the opposite direction; there is then a deeper space, equal to the extent of five vertebræ, in which there are the centrums of three vertebræ and some hæmapophyses irregularly scattered. Beyond this part the terminal caudal vertebræ resume their position and natural connections, and are preserved, seven in number, to the last. The antecedent exceptional violence shown in the caudal series has probably been due to the tugging and gnawing of some predatory animal, whilst this part of the dead and partly decomposed Plesiosaur continued to be exposed at the sea-bottom.

The scapulæ (51) and articular ends of the coracoids (52) appear parallel with the twenty-fifth to the twenty-seventh vertebræ, the left being rather further back than the right. Both humeri (53) have been dislocated at the shoulder-joint by superincumbent pressure, and the articular ends of the scapulæ overlap their heads. The rest of the bones of the pectoral fins have retained their natural relative position, protected by the tough, closely-fitting dermal sheath, until this slowly dissolved away. The iliac bones (62) lie by the sides of the forty-seventh to the fiftieth vertebræ, almost in the axis of the spine, with their proximal ends turned backward, and their acetabular end forward, having become detached from the thick, converging pleura-

pophyses of the forty-seventh and forty-eighth vertebræ (s, s) which overlie the ischium (63) on the left side of the body. The articular ends of the ischium (63) and of the pubis (64) are exposed, retaining their connection with the ilium (62) opposite the forty-third to the forty-seventh vertebræ on both sides. The femora (65) have been slightly dislocated forward, and part of the acetabula is thus exposed.

The bones of the hind fins have preserved their natural relative positions; those of the left side, with their part of the pelvic arch, being a little more backward in position than those of the right, agreeing, in this respect, with the pectoral limbs, and indicating some general movement of the matrix as the cause of such displacement.

Including the atlas and axis there are twenty-four vertebræ before that in which the pleurapophyses have risen, to articulate wholly with the diapophyses (Tab. XII, D). At the forty-fifth vertebra the rib again begins to articulate with the centrum; in the forty-sixth the parapophysis forms the lower half of the costal surface; in the forty-seventh it forms a larger proportion, and the whole costal surface is here suddenly increased in size, giving attachment to a short, slightly bent pleurapophysis of correspondingly and abruptly increased thickness; that of the forty-eighth vertebra is thicker and straighter, and, as the preceding riblet inclines towards its extremity, I conclude that their thick, abrupt, digital ends were ligamentously connected with the iliac bone, and that they therefore may be regarded as sacral vertebræ (Tab. IX, s, s). The remaining vertebræ, from the forty-ninth to the eighty-fourth, will be caudal; thus there may be reckoned 24 cervical, 24 dorsal, 2 sacral, and 34 caudal vertebræ, in the present species.

Perhaps the two vertebræ antecedent to the sacral, in which the centrum shows part of the costal surface, might be regarded as lumbar vertebræ.

The total length of the vertebral column, from the third cervical to the last caudal, following its slight undulations, is 9 feet 9 inches. The skull, from the hind end of the mandible to the fore end of the symphysis, or snout, is 1 foot 11 inches.

The first five or six cervicals, from the third, are more or less obscured by pyritic matter; their neural spines show intervals of from three to six lines; the upper margin of the spine rises obliquely from before backward, with the angle rounded off; it is thickest at the middle part, where it measures two lines; that of the fourth vertebra has a fore-and-aft diameter of seven lines, the same diameter of the ninth is one inch. The pleurapophyses of the tenth vertebra are about an inch in length, with a subcylindrical body, bent obliquely backward, and slightly tapering to an obtuse end. In the eleventh vertebra, the centrum of which is an inch in length, about five lines of free surface intervene between the costal and neurapophysial articulations. From the pleurapophysis to the summit of the neural spine it measures 2 inches 5 lines. At the twelfth cervical the pleurapophyses begin to send forward the process which marks what may be termed the neck or pedicle of the cervical rib.

At the fourteenth cervical the length of the centrum is 1 inch 5 lines; that of its pleurapophysis is 1 inch 9 lines; the fore-and-aft extent of the base of the neural spine is 1 inch 2 lines; the height of the spine is 1 inch 6 lines, and its thickness is 3 lines. The total height of the vertebra is 4 inches. These dimensions are gained by gradual increase from the tenth vertebra. In the nineteenth cervical the length of the centrum is 1 inch 6 lines, the space between the pleur- (ib. *pl*)) and neur- (ib. *np*) apophysial surfaces is 7 lines. From the lower part of the centrum to the summit of the neural spine (*ns*) is 5 inches; the length of the pleurapophysis is 2 inches.

The *Plesiosaurus rostratus* ranks with the section of its genus characterised by broad and short cervical vertebræ. The instructive characters derivable from this region will here be described as they appear in the fifteenth of the series (Tab. X, figs. 1—3). This vertebra gives the following dimensions:

	In.	lines.
Length of centrum	1	6
Height of terminal surface of ditto, or vertical diameter	1	7
Breadth of ditto	2	6
Breadth of the middle of centrum	2	3
From the under part of centrum to the summit of neural spine	4	0
Fore-and-aft extent of neural spine at its middle	1	2
,, ,, neural arch from the end of one zygapophysis to that of the other	2	4
,, ,, neural arch below the zygapophyses	1	1
,, ,, costal surface	0	10
From the costal surface of the base of the neurapophysis	0	8

The terminal articular surface of the centrum is nearly flat, very slightly convex towards the circumference, and similarly concave at the centre; it is transversely elliptical, with a rather thin border, pretty closely co-adapted to that of the contiguous centrum. The sides of the centrum are moderately concave, the under surface is more deeply so; and this is further excavated on each side of an obtuse median ridge (*r*), near which the venous canals open into the large and deep ellipsoid fossæ. The outer boundary of these fossæ is formed by the lower border of the costal articular surface (Tab. X, fig. 3, and Tab. XI, fig. 2 *pl*). The costal surface (Tab. X, fig. 1, *pl*) presents an oval form, with the long axis parallel with that of the centrum, 10 lines in length by 8 lines in breadth, situated at the angle between the lateral and inferior surfaces, and divided by a smooth, non-articular trait of the lateral surface, of 8 lines in vertical extent from the neurapophysial surface of the centrum; this is defined below by a slightly curved subangular border, convex downward. The fore surface of the centrum presents a slightly fibrous character, not so smooth as in some other species, nor so irregular as in the *Pl. rugosus*, for example.

The neural arch is broad and low; the zygapophyses project from nearer the base

of the arch and centrum than in the *Pl. dolichodeirus* (Tab. III, fig. 4) or in *Pl. Bernardi* (for example, Monograph, 1862, Tab. IV, fig. 11), and their articular surfaces are more horizontal, the anterior ones (Tab. X and XI fig. 1, *z*) looking almost directly upward, the posterior ones (ib. *z'*) downward; in this character the present species resembles the *Pl. homalospondylus.* The neural spine is of subrhomboid figure, its height hardly exceeding the fore-and-aft breadth; the anterior border is convex, and rounded off into the upper one, with a scarcely marked angle; the posterior one is slightly concave, the angle between it and the upper border is blunted; the antero-posterior extent of the base of the spine is 1 inch 4 lines, the height of the spine is 1 inch 6 lines. The pleurapophyses (Tab. X, figs. 1 and 3, Tab. XI, fig. 1, *pl*) are not anchylosed to the centrum. Their head, or articular surface (ib. fig. 2 *pl*), forms the thickest part; the bone decreases as it stands outward, especially in vertical diameter, becoming flattened or depressed; it then bends backward, sending a short process forward, like the tubercle of the Crocodile's cervical rib, but developed from the same plane as the head; the backwardly contained body of the rib decreases in horizontal and increases in vertical breadth, presenting a broadly convex surface outwardly (Tab. X, fig. 3 *pl*). The length of the cervical pleurapophysis in the fifteenth cervical here described from the fore part of the head to the posterior point, is 2 inches; from the end of the tubercle to the posterior point is 1 inch 8 lines. The increase in the succeeding vertebræ is most in the pleurapophyses, next in the neural spines, then in the breadth of the vertebra, and least in the length of the centrum; this, indeed, varies somewhat, but not so much as appears in the figure 2 of Tab. XI, in which the matrix is left upon part of the inferior surface in two of the vertebræ.

Resuming the consecutive examination of the spinal column we find, in the twentieth vertebra (Tab. XII, 20), the costal surface rises nearer the neurapophysis (*np*); the rib has attained a length of 2 inches 8 lines. In the twenty-first (ib. 21) the costal surface reaches the neurapophysis (*np*), which contributes a little to its upper part by a diapophysial projection. The vertical extent of this costal surface is 1 inch, the length of the pleurapophysis is nearly 3 inches. In the twenty-second vertebra half the costal surface is formed by the diapophysis. The length of the rib (*d*) is 3 inches 9 lines; the anterior process or tubercle becoming shortened. It is shorter in the next rib (*pl*), the body of which is longer; and on the rib of the twenty-fourth vertebra it has disappeared. In the twenty-fifth vertebra (ib. D 1) the diapophysis (*d*) is prominent, and forms the entire costal surface. The ribs of this instructive series of six consecutive vertebræ have been dislocated from their articulations, apparently by the operation of the pressure which rotated the rest of the vertebræ from the vertical to the lateral position, but they retain their relative positions to each other, the end of one extending beyond and below the fore part of the next, and, in a greater degree, as the vertebræ approach the back. The sides of the neural spines of these vertebræ are roughened by irregular or granulate ridges, directed toward their

summit, which is bent backward. The dorsal vertebræ continue to increase in the length and size of the diapophyses, in the height of the neural spines, in the breadth and depth of the centrum, and, by a still greater degree, in the length of the ribs; in every dimension, in short, except that of the length of the centrum, which, in the tenth dorsal, is 1 inch 10 lines, and in no dorsal vertebra exceeds 2 inches. The breadth of the centrum in the tenth dorsal is 3 inches; the height, 2 inches 3 lines; the articular surface is moderately hollow at the middle, and gently convex towards the periphery; the neural spines gradually attain the height of $3\frac{1}{2}$ inches towards the end of the series, the fore-and-aft extent being about $1\frac{1}{2}$ inch near the summit, which is more thickened and truncate than in the neck, measuring, in some of these vertebræ, 9 lines in thickness. Both margins are concave at the lower half of the spine, and the intervals between those of different dorsal vertebræ average about three fourths of an inch at the narrower parts of the spines. The length of the diapophysis is about $1\frac{1}{2}$ inch; it expands to its extremity, which is abruptly truncate, looking obliquely outward, backward, and a little downward; it is flat, and rather rough, for ligamentous union with the rib; subquadrate in form, averaging about an inch across. The ribs attain their greatest length from the twelfth to the fifteenth dorsal, where they are 1 foot 6 inches in length, with a simple expanded end, corresponding in shape and size with the diapophysial surface; the body of the rib is subcylindrical, then sub-trihedral, and again subcylindrical in shape, about 6 lines in diameter at the narrower part, and gradually enlarging at the distal third to the truncate extremity, which was ligamentously connected with the sternal rib. Some of the longest ribs have suffered fracture, and some contortion at their middle slender part, in the course of the cosmical pressure which has spread them out flat; but they retain much of their natural curvatures on each side the vertebral column. After the thirteenth, the ribs gradually decrease to a length of $3\frac{1}{2}$ inches, in the last vertebra, in which the rib articulates wholly with the diapophysis (twenty-second dorsal), the breadth of this rib is 5 lines. Where the rib begins again to descend from the centrum, it continues to decrease in length in the first and second, in the latter of which it begins to gain in thickness. In the forty-ninth vertebra, counting from the skull, which vertebra I have indicated (Tab. IX, s) as the first sacral, the rib is 2 inches 6 lines in length, and 9 lines in least diameter; its head is partly buried in the matrix, but the articular surface next the vertebra from which it is detached is 2 inches in vertical and 1 inch in longitudinal diameter, and the surface projects below, from the centrum, as it does above, from the neural arch. The borders of the terminal articular surfaces of the centrum are thicker and rougher than those of the dorsal or caudal vertebræ, indicating a stronger connection between the vertebræ from which the pelvic arch was suspended. The rib of the second sacral is straight, $2\frac{3}{4}$ inches in length, and 13 lines in the smallest diameter.

In the caudal vertebræ the neural spines gradually decrease in length, but more so in antero-posterior breadth, being longer, and with wider intervals at the basal half of

the tail than in the neck. The pleurapophyses continue to articulate in part with the neural arch to the tenth or twelfth caudal vertebra; the pleurapophyses are straight, and have gradually diminished to a length of $1\frac{1}{2}$ inch in the tenth caudal; they are flattened, and slightly expand towards the fore extremity, which, in the one above cited, there measures 10 lines across; the hæmapophyses are distinctly shown, those of each pair being separate, beneath the centrums of the seventeenth, eighteenth, and nineteenth caudals, forming part of that series where the neural spines are turned to the left. The first of these hæmapophyses has a length of 1 inch 9 lines, and a fore-and-aft breadth of 6 lines at its compressed, dilated, free extremity. The articular surface of the centrum of the twentieth caudal vertebra is exposed; it is gently concave, with a central depression, 1 inch 3 lines in vertical and nearly the same in transverse diameter, with an inferior border bevelled off at the fore part, for the articulation of the hæmapophyses. The ten terminal caudals show the lateral compression and flattening, with suppression, first of the posterior then of the anterior zygapophyses; next of the neural spine, and, in the last three or four, of the neural arch itself. Traces of hæmapophyses may be distinguished as far as the twenty-ninth caudal. This compression of the centrums would indicate, by cetacean analogy, some development of the terminal dermal expanse, but in a vertical, not horizontal, direction.

Reckoning the dorsal series of vertebræ as twenty-four in number, it constitutes rather more than one third of the whole extent of the spinal column; the thirty-four caudal vertebræ, of smaller proportions, constitute another third; the twenty-four cervicals are rather less than a third. The skull is equal in length to three fourths of the neck and to one sixth of the entire skeleton. The total length of the vertebral column is 9 feet 9 inches, the total length of the skeleton being 11 feet 8 inches.

The skull (Tabs. IX and XIII) is 1 foot 11 inches in length, 9 inches in breadth across the mastoids, $7\frac{1}{2}$ inches across the back of the orbits, but here it appears to have been somewhat flattened out by pressure. It is 5 inches 3 lines broad in front of the orbits, 2 inches across the narrowest part of the snout, which, from the fore part of the orbit, is $11\frac{1}{2}$ inches in length, and expands at its extremity to a breadth of $2\frac{1}{2}$ inches. This is the proportion of the snout which gives the peculiar and distinctive character to the present species of *Plesiosaurus* and which suggested *rostratus* as the specific name; in fact, the head, from the aspect exposed, resembles rather that of the Muschelkalk *Pistosaurus* than that of any of our heretofore known Liassic *Plesiosauri*.

The temporal fossæ are oblong, contracting anteriorly, and are there outwardly rounded off; in length 5 inches; in breadth, posteriorly, 3 inches. The subcircular orbits are 2 inches in diameter. The narrow elliptical nostrils are $1\frac{1}{2}$ inch in advance of the orbits. The upper and hinder boundary of the cranium, formed by the bifurcate parietal, and strong, overlapping mastoids, is convex superiorly, expanding as it proceeds outward. The middle part of the parietal rises into a sharp crest

between the temporal fossæ, and a continuation of the same crest, whose sides slope away from each other at a right angle, characterises the upper part of the frontal to midway between the orbits. The postfrontal bar, or flattened tract, dividing the orbital from the temporal fossæ, is an inch in breadth. The narrow nasals are divided by a medial suture, and, with the prefrontal and lacrymal, separate the orbit from the nostril.

The lower jaw has slipped from beneath the cranium, and, by the effect of the gradual pressure, has been turned, with the flatter left side upward. The angle projects beyond the articular surface 2 inches 3 lines, terminating obtusely, slightly bent, with the concavity upward, and 1 inch in thickness. The great part of the articular cavity of the right ramus is exposed, showing a transverse diameter of 1 inch 3 lines, and a fore-and-aft diameter of 10 lines: it is concave lengthwise, sinuous across. In advance of the articulation the ramus shows a depth of $1\frac{1}{2}$ inch, gradually increasing to that of 2 inches 3 lines, and then contracting vertically toward the dentary part; the deepest portion, formed by the angular and sub-angular elements, is situated about four inches in advance of the articular cavity, and there the thin outer parietes of the ramus have been crushed in, yielding to the superincumbent pressure.

The length of the dentigerous part of the jaw is 1 foot 2 inches; externally the dentary descends vertically from the sockets containing the teeth, but internally it swells out into a strong, convex, longitudinal tract, strengthening the alveoli, until the two dentaries meet at the symphysis. There is a longitudinal groove at the middle of the inner surface, below which the bone again swells out and is continued into the thick under surface of the dentary. The length of the symphysis is nearly 7 inches; and here the vertical extent increases, and terminates more sharply below. The vertical extent of the dentary, behind the symphysis, is 1 inch, the deepest part of the symphysis is $1\frac{1}{2}$ inch; the outer surface of the symphysis is coarsely and irregularly rugose; its upper border is scooped out at the alveoli for the larger teeth; on the left side there are about twenty-two sockets for teeth of different sizes; the smallest are behind, and the hindmost shows a straight crown (Tab. IX, fig. 6), sloping forward, from 4 to 5 lines long, with the usual longitudinal ridges of the enamel. The tooth in advance is slightly bent; the eighth in advance shows a crown, 9 lines in length; the fifteenth in advance (Tab. IX, fig. 4) shows a sudden increase of size, and greater degree of backward curvature; including this, eight teeth occupy the rest of the alveolar surface, which is coextensive with the symphysis. Here the teeth are divided by intervals of rather more than their own basal breadth; the largest tooth (ib., fig. 3), following the curvature, has a crown two inches in length. The longitudinal enamel-ridges begin at from one to two lines above the base of that covering of the crown, where it is smooth, and they terminate about the same distance from the apex; they are least developed at the outer, convex part of the upper half of the crown. Two of these large, laniary teeth project from the anterior alveolus, the outer and

anterior tooth being about to be shed. The right side of the symphysial part of the jaw (Tab. IX, fig. 2) contains nine teeth, the third, fifth, and seventh being the largest. The fifth (Tab. IX, fig. 5) measures 2½ inches in length of crown, following the curve. The fourth and sixth teeth were emerging from sockets larger than themselves, and are successional teeth. The unusual length of the symphysis corresponds with the prolongation of the premaxillary above.

In the same locality and formation with the skeleton above described was discovered the portion of skull, corresponding in size, and, so far as it is preserved, in shape with that of the skeleton of the *Plesiosaurus rostratus*, to which species, therefore, I provisionally refer the specimen (Tab. XIII). It includes the basi-occipital, right ex-occipital, basi-sphenoid, portions of pterygoids, ecto-pterygoids, palatines, with fragments of the maxillary and of the right ramus of the mandible. In the figures of this specimen (Tab. XIII) the mandibular part is omitted. The left ex-occipital is wanting; the right (ib., 2) is displaced, so that the whole of the upper part of the basi-occipital (ib., 1) is exposed. This shows that the bases of the ex-occipitals are divided from each other by a narrow tract, and that the basi-occipital forms the whole of the condyle and of the median part of the floor of the epencephalic compartment of the cranium; this part of the bone (1) measures across its most contracted portion about three lines. The condyle is subhemispheric, with the transverse diameter rather the longest, and with a slight and irregular depression a little above its centre. The upper border of the condyle (fig. 1) is on a level with the advanced epencephalic surface (1) of the basi-occipital, from which it is divided by a shallow and narrow transverse channel; the lower border (fig. 2, *o*) projects abruptly downward, and is divided from the more advanced surface of the basi-occipital by a transverse furrow, three lines wide and four or five lines deep. The surface of the basi-occipital is covered by the posterior border of the pterygoids (24) which underlie it, extending backward, so as to leave only parts of the pair of rough and tuberous basi-occipital processes (*h*, *h*) exposed. The posterior part of the epencephalic surface of the basi-occipital (Tab. XIII, fig. 1, 1) is smooth and concave transversely; but, as it advances, it becomes irregular and expands, and apparently is divided by an irregular protuberance at the middle part. The neurapophysial surfaces (*n*, *n*) on each side are, as in the succeeding centrums, triangular, with the angles rounded off. About a line in advance of these is the 'harmonia,' or straight suture, indicating the flat synchondrosis by which the epencephalic unites with the mesencephalic centrum (basisphenoid, ib., 5), thus repeating the kind of union which attaches the centrum of the atlas to that of the axis vertebræ. The neural surface (5) expands to a greater breadth than it had attained in the basi-occipital, measuring fourteen lines across; it has a smooth, undulating surface, moderately concave in the middle, where it sinks below the level of the epencephalic surface (1). The sides of the mesencephalic surface are bounded by a narrow ridge, seemingly an exogenous growth from the centrum, as in some modern

Lacertilia, to which 'neurapophysial' ridges (Tab. XIII, fig. 2, *n*, *n*) may have been attached the neurapophyses, but retaining, as in these *Lacertilia*, more or less of their primitive histological fibro-cartilaginous condition. The under and lateral parts of the mesencephalic centrum, called 'basisphenoid,' are covered by the largely developed 'pterygoids' (ib., fig. 1, 24),—the diverging appendages of a more advanced cranial segment. The back part of the third or 'prosencephalic' centrum has coalesced with the second, the boundary-line being indicated by a shallow depression, which may have lodged the vascular appendage of the brain called 'hypophysis,' or 'pituitary gland.' The sides of this part of the centrum rise, neurapophysially, and terminate with a fractured and worn surface, and the rest of the centrum, answering to the cetacean 'presphenoid' (9), has been broken away. Beneath the fractured end of the presphenoid is the nasal 'meatus,' or canal (ib., fig. 1, *r*), which is divided below by the junction of the palatines (ib., fig. 2, 20, 20) with the pterygoids (ib., 24, 24), so as to open upon the roof of the mouth by a pair of posterior or palatal nostrils 'palatonares' (ib., *r*, *r*). These are of a narrow, elliptical form, with the long axis longitudinal, but slightly, inclined 'mesiad,' or converging anteriorly, pointed behind, 1 inch 6 lines in long diameter, 7 lines across their widest part, and separated anteriorly by a tract of bone 9 lines across; from the posterior end of the 'palatonares' to the same part of the basi-occipital tuberosity is 1 inch 5 lines. The palatines (ib., fig. 2, 20, 20), where they give attachment to the pterygoids, are narrow, rather thick, with a shallow median channel, bounded by low, lateral, obtuse risings; external to these the palatines form the anterior ends of the 'palatonares,' and thence expanding, and flattening as they stretch forwards, they unite laterally with the ectopterygoids (25, 25). The pterygoids (24, 24), which form the inner and posterior boundaries of the palatonares, expand as they pass backward, become thinner and flatter, and retain a sutural union along the mesial line until they reach the precondyloid fossa of the basi-occipital; underlying and concealing from view, inferiorly, the basi-presphenoid and major part of the basi-occipital. These 'basilar' plates are slightly concave from side to side, and are divided from the 'tympanic' processes (24', 24') by a rising of bone, hardly to be called a ridge; this is chiefly formed by the concavity or sinking of the surface at the commencement of the under part of the 'tympanic' process, which also gradually contracts in breadth as it extends backward and outward to abut against the tympanic pedicle (28), which is wedged at its upper or cranial half between the pterygoid (24) and par-occipital (3).

The ectopterygoid (ib., fig. 2, 25) articulates with the pterygoid near the posterior part of the palatal nostril, where it is about seven lines in breadth; this joint has been put out by pressure on the right side and the ectopterygoid dislocated downward; the corresponding part is broken off on the left side, where it overlaps the pterygoid, forming the outer boundary of the palatal nostril. The ectopterygoid expands as it advances forward; curving, mesially, round the fore part of the nostril to join the

palatine (20), and laterally to join the maxillary (21), of which a fragment is preserved in this crushed specimen. The lower opening of the temporal fossa is bounded mesially in nearly equal proportions by the pterygoid and ectopterygoid.

Estimating the length of the skull in the present specimen at two feet, about six inches in length of the hind part is here preserved; and the palatal nostrils open chiefly upon the hinder half of this part. In their posterior position, therefore, they agree with those in *Teleosaurus*, but differ in being divided by the medial productions of the palatines and pterygoids, and in not being confluent, as a single aperture, as in the *Crocodilia;* thus they exemplify the more general Reptilian character as it is preserved in our modern *Lacertilia.*

In the *Nothosaurus* the palatonares are two; but they open upon the anterior fourth part of the bony palate, having their hinder boundary formed by the palatines instead of their front one. In *Pistosaurus* the palatonares are situate about midway between the fore and back part of the long and narrow bony palate. In all *Sauropterygia* the pterygoids present much of their crocodilian character in their posterior extension and expansion, underlying the posterior cranial centrums and covering, in this way, in *Plesiosaurus,* more of the basi-occipital than in the crocodiles. Some portions of long, slender, subcompressed bones adhering to the present instructive fragment of the plesiosaurian cranium may have belonged to the hyoidean arch; one of them (40) adheres to the bony palate, and partly conceals the left palatal nostril in fig. 2.

Pectoral and pelvic arches and limbs (Tab. IX).

The scapula (Tab. IX, 51) is 5 inches in length; smooth and convex externally at its narrow upper part, where it shows a breadth of 10 lines; it rapidly expands to a breadth of 3 inches at its humero-coracoid extremity, which overlaps, as before mentioned, the head of the dislocated humerus. The outer surface of the articular end of the scapula is roughened by longitudinal ridges.

The humerus (ib., 53), showing a breadth of 1 inch 9 lines where it emerges beneath the scapula, expands to a breadth of 4 inches where it is articulated to the antibrachial bones; its anterior border is straight, less convex at the distal half than in *Pl. dolichodeirus;* less expanded at the distal end than in *Pl. homalospondylus.*

The radius (ib., 54) is 3 inches 2 lines in length, 2 inches broad at its proximal end, 1 inch 9 lines at its distal end; with a thin, straight, somewhat irregular anterior border, and a thicker, smooth, concave posterior border. The ulna (ib., 55) presents the usual reniform figure, with the concavity toward the radius; it is of the same length as the radius, but is flatter; 2 inches 3 lines across its middle part; the margin next the radius is rather more concave than that which it opposes; the

opposite margin of the ulna is very convex; the distal end is divided by a low angle between the surfaces for the outer and middle carpals of the proximal row.

The carpal bones are six in number, three in each row. The proximal ones are the largest, but, of this row, the radial carpal, or 'scaphoid,' is least; it is of a transversely oblong figure, with its distal border divided by a low angle between the radial and the middle bones of the second row; this relation is better shown in the right than in the left pectoral fin. The middle proximal carpal, or 'lunare,' is the largest, of a sub-hexagonal form; the shortest side, toward the radius, is concave; the side opposite the radial carpal is rather convex; the other facets for the ulna, ulnar carpal ('cuneiforme') and the two larger carpals of the second row, are nearly straight. The three carpals of the second or distal row increase in size from the radial to the ulnar side of the waist; the outermost being surrounded by three carpals and three metacarpals; the metacarpal of the fifth digit extending along its ulnar side to articulate with the ulnar carpal of the first row. In its relations to the metacarpals, the largest of the second row resembles the 'magnum' and 'unciforme' combined, of the mammalian carpus. The next in size answers to the 'trapezoides,' supports the second metacarpal, and, at its opposite border, fills the interspace between the radial and middle carpals of the first row. The radial carpal of the second row is the smallest of all; it is wedged between that of the first row, the first metacarpal and the middle carpal of the second row: it answers to the 'trapezium.'

The first metacarpal (ib., 56) is the shortest, 1 inch in length, it supports two phalanges, the last of which is 10 lines in length; the whole length of this digit, including the metacarpal, is 2 inches. The second metacarpal is 1 inch 9 lines in length, and supports six phalanges, the last being 4 lines long; the total length of this digit, including the metacarpal, is 10 inches 6 lines. The middle metacarpal is 1 inch 10 lines in length, it supports eight phalanges; the total length of this digit, including the metacarpal, is 10 inches 6 lines. The fourth metacarpal is 2 inches in length, it supports seven phalanges; the total length of the digit, including the metacarpal, is 10 inches. The metacarpal of the fifth digit is $1\frac{1}{2}$ inch in length, its proximal breadth is 1 inch; that of the first metacarpal being half an inch, and that of each of the three intermediate metacarpals ranging from 9 to 10 lines; the outermost metacarpal supports seven phalanges: the total length of the digit, including the metacarpal, is $9\frac{1}{2}$ inches; the fifth metacarpal, besides being shorter and broader than the three middle ones, is more convex, and obliquely bevelled off at its proximal end, the radial side being shorter than the ulnar one. The phalanges of the fifth digit are more concave at their outer or ulnar border than the others. The first metacarpal is more concave at its radial border. All the phalanges are flattened and expanded at their extremities, the outer surface showing linear impressions, the middle part being smooth. The total breadth of the carpus is 4 inches 5 lines. The total length of the hand is 1 foot 1 inch. The total length of the pectoral limb seems to have been about

2 feet. It is much shorter in proportion to the trunk (as reckoned from the first dorsal (ib., fig. 1, D) to last sacral (ib., S) than in the *Plesiosaurus homalospondylus* (Tab. V), and differs in the more proximal position of the metacarpal of the fifth digit, and in the smaller size of the radial carpal of the distal row.

Like the scapula in the pectoral arch, the ilium (Tab. IX, 62) is the smallest bone of the pelvic one; it is 5 inches in length, $1\frac{1}{2}$ inch across the obliquely truncate upper (proximal or sacral) end, it contracts to a diameter of 9 lines at its middle, and then expands to a breadth of 2 inches 4 lines, with proportional thickness, at its lower acetabular end. The stem is subcompressed, convex transversely, and also longitudinally at the upper half, which shows a low ridge externally, and is longitudinally striate near the margin of the surface connected with the sacral pleurapophyses, from which, as before stated, it has been dislocated. The acetabular end preserves its natural connections with the corresponding thickened part of the ischium (ib., 63), which on both right and left sides is interposed between the ilium and pubis. The rough acetabular surface is nevertheless continued from the ischium upon the pubis, for about two inches of the contiguous border. The head of the femur is applied to the ischio-pubic surface in both limbs, yet the better proportioned articular depression is that formed by the ilium and ischium, from which it seems as if the femur had been dislocated forward. As, however, the mode of attachment has been by a ligamentous mass, this may have converged from the whole of the antero-posteriorly extended acetabular surface to the head of the thigh-bone, allowing a certain freedom of play of the bone forward and backward; the diameter of such acetabular surface, lengthwise, is 5 inches, the greatest vertical diameter is 3 inches.

The ischium (Tab. IX, 63), as it passes from the acetabulum mesiad, loses its thickness and expands into a plate of the usual triangular form, the posterior apex of which is seen on the left side behind the two overlying sacral ribs, stretching as far back as the ilium (ib., 62); from this apex, or angle, to the acetabular junction with the pubis, the ischium measures 8 inches. Pyritic matter intervenes between the ischium and sacral ribs, on the left side.

So much of the pubis (Tab. IX, 64) as is visible on the left side exhibits the usual subcircular discoid shape, with the two facets on the thickened part of the margin, one for articulation with the ischium, the other completing the fore part of the acetabular tract. The broadest part of the exposed pubic disk measures 6 inches lengthwise.

The femur (Tab. IX, 65) is 9 inches 9 lines in length. A longitudinal notch feebly marks out a trochanteric part of the thick, convex, articular head; this is coarsely pitted for the ligamentous insertions. The shaft contracts, chiefly losing thickness, and becoming lamelliform as it expands in breadth to the distal articular surface. This is convex, curving in a greater degree at its hinder part. Both anterior and posterior borders of the shaft are concave; the former least so, but to that extent differentiating the femur from the humerus, in which it is straight, or rather convex.

The distal breadth of the femur is 4 inches 8 lines; the non-articular surface is smooth, except near the two ends, where there are rough, longitudinal ridges and depressions, indicative of ligamentous insertions.

Both tibia (Tab. IX, 66) and fibula (ib., 67) are broader in proportion to their length than their homotypes in the fore limb. The posterior distal angle of the fibula is more decidedly truncate, for articulation with the middle tarsal, than is the corresponding part of the ulna. The inter-osseous space is a long ellipse with pointed ends, about an inch in width across the broadest part.

The tarsus (Tab. IX, 68), like the carpus (ib., 56), consists of six bones, in two rows of three each. The tibial bone of the first row is broader, in proportion to its length, than its homotype in the carpus; and this is the proportional character of all the bones of the tarsus, save that which intervenes between the fibula (67) and the fifth digit (69), the metatarsal of which passes outside the distal tarsal series.

The metatarsal of the innermost tibial, or first digit, is 1 inch 4 lines in length, 10 lines in breadth, and supports three phalanges; the total length of the digit, including the metatarsal, is 4 inches 8 lines. The metatarsal of the second digit is 1 inch 9 lines in length, and supports six phalanges, the last being 4 lines in length; the total length of this digit, including the metatarsal, is 8 inches 6 lines. The metatarsal of the mid-digit is 2 inches in length, and supports nine phalanges; the total length of this digit, including the metatarsal, is 1 foot. The metatarsal of the fourth digit is 1 inch 11 lines long; the fibular side of its base is more produced than in the others; it supports a digit of eight phalanges, and this, including the metatarsal, is 1 foot 1 inch in length; the metatarsal of the fifth digit is 1 inch 10 lines in length, and supports six phalanges, the last of which is broader and flatter than in the other digits; the total length of the fifth digit, including the metatarsal, is 10 inches 2 lines. The breadth of the leg is 5 inches 5 lines; the length of the tibia 3 inches; that of the fibula 2 inches 9 lines. The breadth of the metatarsus is 4 inches 7 lines. The total length of the hind limb is 2 feet $4\frac{1}{2}$ inches. The hind limb, though longer and larger than the fore limb, repeats the character of relative shortness in proportion to the trunk, as engraved with the same parts in *Plesiosaurus homalospondylus.* The neural spines of the trunk are shorter, with wider intervals, exemplifying the superior vigour and locomotive power of the longer-necked and larger-finned species (Tab. VIII.)

We see in *Pl. rostratus* a correlation of the size of the head with that of the anterior laniary teeth, and with the shortness of the neck. But the head is proportionally less compared with the trunk, and the neck is shorter, and has fewer vertebræ, than in the *Pl. macrocephalus.** These characters, with the greater lengthening and attenuation of the muzzle in *Pl. rostratus,* indicate a nearer step in affinity toward the Teleosaurian marine reptiles.

* 'Geological Transactions,' 2nd series, vol. v, pl. xliii.

Plesiosaurus rugosus, *Owen.* Tabs. XIV and XV.

This species, originally indicated by characters of detached vertebræ,* has received ample elucidation from the fine specimen (Tab. XIV) presented by His Grace the Duke of Rutland, K.G., to the British Museum. It was obtained from the zone of Lower Lias of Leicestershire, characterised by the *Ammonites stellaris,* in the neighbourhood of Granby.

This specimen of the *Plesiosaurus rugosus* presents a similar condition to that of the *Pl. dolichodeirus* decribed by Conybeare,† save that the head is not preserved in advance of the small, scattered vertebræ of the anterior part of the neck; about five-and-twenty vertebræ of this region preserve their consecutive arrangement, most of them in almost a straight line. The vertebræ of the trunk have suffered a greater degree of dislocation, and, the specimen having been exposed in a prone position, they are so dispersed as to permit to be seen the upper or inner surface of the coracoids, the abdominal ribs, and the pubic and ischial bones. Two thirds of the caudal vertebræ show the same scattered and dislocated condition; but nine near the end of the tail have preserved their natural position, as consecutively articulated, and apparently their true relative position to the trunk. The four paddles are preserved outstretched, as naturally articulating with their respective arches of support, with the superior or external surface of the bony framework exposed.

The cervical vertebræ, which have retained their natural consecutive arrangement and juxtaposition, have undergone the same partial rotation as is observable in most Plesiosaurian skeletons from Liassic beds, presenting their broadest surface or sides to view; the neural spines have here rotated toward the left side. Besides the twenty-five cervical vertebræ which are more or less consecutive, three or four are huddled in a heap at the base of the neck, and five or six are scattered at its fore part. From the size of the articular surface of the foremost of these, which measures but six lines in diameter, as well as from so much of the length of the neck as is demonstrated, it may be inferred that the head was small, as in the *Pl. dolichodeirus.*

Cervical vertebræ (Tab. XV).

One of these vertebræ, corresponding in position to the fifteenth cervical of the *Pl. rostratus* (Tab. X), was carefully wrought out of the matrix of the specimen Tab. XIV, and is represented of the natural size in Tab. XV. Its proportions show that the present species, like *Pl. dolichodeirus* and *Pl. Hawkinsii,* belongs to the section

* 'Report on British Fossil Reptiles,' 1839; 'Reports of the British Association,' 8vo, 1840, p. 82.

† 'Trans. Geol. Soc.,' tom. cit.

characterised by intermediate proportions of the centrum, neither "long," as in *Pl. homalospondylus,* nor "short," as in *Pl. rostratus* and *Pl. planus.* The following are the dimensions of this vertebra:

	In.	lines.
Length of centrum	1	9
Height or vertical diameter of terminal surface of ditto	1	9
Breadth of ditto	1	10½
,, the middle of centrum	1	7
From the under part of centrum to the summit of neural spine	4	4
Fore-and-aft extent of neural spine at its middle	1	4
,, ,, ,, arch from the end of one zygapophysis to that of the other	2	6
,, ,, ,, arch below the zygapophyses	1	3
,, ,, costal surface	0	7
From the costal surface to the base of the neurapophysis	0	11

The free or non-articular surface of the centrum shows near the margins of the terminal surfaces the strongly marked rugous character which originally suggested the specific name in the detached vertebræ. The irregular risings of bone lie chiefly in the direction of the axis of the vertebra, and project so as to come into view exterior to the articular surface in an end-view of the centrum, as in Tab. XV, fig. 2. The sides and under part of the centrum are moderately concave lengthwise. The contour of the terminal articular surface is circular; its border is thick and convex, leading to a moderate concavity, with the central part rising into a slighter convexity. The costal pits (*pl*) are of a full elliptical form, with a slightly prominent margin, situated near the lower surface of the centrum, a little nearer the hind than the fore end, and with twice their own vertical diameter intervening between them and the base of the neurapophysis (*np*). This part of the side of the centrum is traversed by a low, longitudinal rising, a little nearer the neur- than the pleur-apophysis. The venous orifices on the under surface of the centrum (Tab. XV, fig. 4) are two and a half lines apart, with an intervening low, obtuse, longitudinal ridge, and are not situated in definite depressions. The lower border or base of the neurapophysis has not the angular form seen in *Pl. Hawkinsii* and *Pl. dolichodeirus,* but is curved. The neurapophysis rises, with both fore and hind borders vertically concave, transversely convex, about five lines above the centrum before giving off the anterior zygapophyses (*z*); the posterior arcs (*z'*) come off, as usual, a little higher. The neural spine is subquadrate, more angular between the fore and upper margins than in *Pl. rostratus* (Tab. X, fig. 1); the thickness of the spine is shown in Tab. XV, fig. 2; the front border is sharp. The chief variety observable in cervical vertebræ of the present species is the presence of the longitudinal groove bisecting the costal surface. The articular surface of the centrum in every cervical vertebra where it is exposed in the present skeleton repeats

the character of the one described; but some, at the base of the neck, have the central rising rough, and with a small pit in the middle. The same character is continued throughout the dorsal series, and the concavity is exaggerated in the vertebræ of the tail, which are, however, more concave than the others in all *Plesiosauri.*

	Ft.	In.
The total length of the specimen preserved is	10	6
The length of the cervical region preserved is	4	0
From the fore part of the coracoid to the hind part of the ischium . .	3	6
From the ischium to the end of the tail as far as preserved	3	3
The transverse breadth of the pubic bones across their broadest part is . .	1	$1\frac{3}{4}$
The fore-and-aft diameter of pubis at its middle part is	0	$5\frac{1}{2}$

Scapular arch and appendages (Tab. XIV).

The humerus (Tab. XIV, 53) is 10 inches long, $2\frac{1}{4}$ inches across its middle narrowest part, and $4\frac{3}{4}$ inches across its distal broadest part. The outer part of the head is somewhat produced, with a slight longitudinal depression on each side; its surface is tuberous and rough; there is a low tuberosity on the hind part of the humerus, below its head. The contour of the anterior border of the bone is nearly straight, slightly wavy, first concave, then convex, again concave and more convex as it is rounded off to the lower border. The posterior margin is more deeply concave from the upper tuberosity to the posterior angle, which is rounded off. The distal margin, convex in a general way, has its two surfaces sufficiently defined for the radius and ulna; they do not, however, meet at so well-defined an angle as in some species; a space of about an inch intervenes here between the radius and ulna in both right and left limbs, whereas they meet and touch each other in the *Pl. dolichodeirus* (fig. 5) and *Pl. Hawkinsii* (fig. 6). The shaft of the humerus shows a tolerably smooth and longitudinally fibrous surface, but has a rough tuberculate character for about an inch and a half from the distal articulations.

The radius (Tab. XIV, figs. 1 and 2, 54), 4 inches in length, is 2 inches 9 lines across the proximal end, 1 inch 10 lines across the distal end, 1 inch 6 lines across the middle. The radial or anterior margin is produced and somewhat thickened below the head, making the margin beyond it concave half way towards the distal end; the posterior or ulnar border is uniformly and moderately concave; the distal border of the radius is straight from its ulnar angle to near its radial one, where it becomes convex, that angle being, as it were, cut off. This distal border is most closely articulated, seems, indeed, partially confluent, with the scaphoid. The ulna (Tab. XIV, figs. 1 and 2, 55) would present its usual reniform shape, were it not that the proximal angle of the posterior or ulnar border is produced into a sort of olecranon (fig. 2, 55'). This process is separated by a fissure or fracture from the body of the bone; but as this

occurs in the same place and with the same course in both forearms, I infer it to be natural, and that the quasi-olecranon was of the nature of a sesamoid, closely articulated with the body of the ulna. The extreme length of the ulna, from the apex of this part or process (55′) is 5 inches; the greatest breadth of the ulna 3 inches. The proximal articular surface joins the ulnar facet of the humerus, beyond which the olecranon projects. The distal surface of the ulna articulates with the lunare (*l*), the cuneiforme (*c*), and with an ossicle (*p*) wedged into the interspace posteriorly between it and the ulna, which ossicle may represent the pisiforme. With the exception of about one third of the middle of the shaft, the exposed surface of both radius and ulna is roughened by coarse rugæ and small tubercles.

The carpus includes eight ossicles. The scaphoid (fig. 2, *s*) is an oblong bone, with its dimension greatest transversely, viz., 2 inches, longest at its ulnar side, which is 1 inch 3 lines, with a slight angular projection at its free radial border. The lunare (ib., *l*) is subreniform, with the concavity, representing the "pelvis of the kidney," completing the lower part of the inter-osseous space, for the radius and ulna are separate below as well as above, and for a greater extent, the radius extending for nearly an inch below or beyond the ulna. The rest of the circumference of the lunare is divided more or less distinctly into its articular surfaces for the radius, scaphoides (*s*), trapezoides (*z*), magnum (*m*), cuneiforme (*c*), and ulna. The ulnar surface has a sigmoid form. The lunare (*l*) is larger than the scaphoid. The cuneiforme (*c*), about the size of the lunare, has a subhexagonal shape; the two proximal sides articulate with the ulna and pisiforme (*p*), the radial side with the lunare, the ulnar side with the unciforme (*u*), the two distal sides with the magnum (*m*), and the base of the fifth metacarpal (*v*), which, as in some other *Plesiosauri*, ascends above the rest to this connection, severing, so to speak, the unciforme (*u*) from the magnum (*m*). The pisiforme (*p*) is a subtriangular small bone, wedged into the outer interspace between the ulna and cuneiforme. In the distal row of carpals the trapezium (*t*) is subquadrate, broader toward the scaphoid, narrower where it supports the first metacarpal (I); it is about half the size of the scaphoid. The trapezoides (*z*) is also subquadrate, but of larger size, articulating with the scaphoid, trapezium, the ulnar angle of the base of the first metacarpal, wholly sustaining the second metacarpal, articulating with the radial side of the base of the third metacarpal, with the os magnum (*m*), and with the lunare (*l*). The os magnum (*m*), of similar size, is hexagonal; the two proximal surfaces articulate with the lunare and cuneiforme, entering the angle which they leave; the two distal surfaces articulate with the third and fourth metacarpals; the radial side with the trapezoides, the ulnar side with the corresponding part of the base of the fifth metacarpal; the displaced outermost bone of the distal row is limited to its articulation with the ulnar border of the cuneiforme (*c*); it is the smallest of the carpal series.

The bones of the digits are small in comparison with those of the carpus and forearm. The entire breadth of the carpus being 6 inches 5 lines, that of the middle of

the metacarpus is 5 inches in the left hand, and but $4\frac{1}{2}$ inches in the right, both being preserved in their natural connections as they were buried, but one showing a more expanded, the other a more contracted, condition of the fin.

The first metacarpal (Tab. XIV, fig. 2, I) is 1 inch 9 lines in length, and supports two phalanges; the total length of that digit, including the metacarpal, being 4 inches 3 lines. The second metacarpal (ib., II) is 2 inches 3 lines in length; it supports five phalanges; the total length of the digit, including the metacarpal, is 9 lines. The third metacarpal (ib., III) is 2 inches 8 lines in length; it supports five phalanges; the total length of the digit, including the metacarpal, is 9 inches 9 lines. The fourth metacarpal (ib., IV) is 2 inches 5 lines in length; it supports four phalanges, and is the same length with the preceding. The fifth metacarpal (ib., V) is 3 inches 3 lines in length, with its ulnar margin more deeply concave than in the others; it supports four phalanges, most of which show the same deeper concavity, with a greater production of the ulnar ends of the articular expansions; the total length of this digit is 8 inches 6 lines; a distal phalanx is wanting in it, and the same may likewise be the case with the others.

There is a want of precise symmetry in the proportions of the right and left fore paddles, those of the right being longer and somewhat slenderer than those of the left.

The whole of the outer surface of the carpal bones is rugose, as is the chief part of that of the metacarpals and phalanges. The total length of the bones of the right pectoral limb, as here preserved, is 2 feet 3 inches; the breadth of the antibrachium is 6 inches 6 lines; that of the carpus 6 inches; that of the metacarpus 5 inches; the interspace between the heads of the two humeri is 1 foot 6 lines.

Pelvic arch and limbs (ib.).

The iliac bones (Tab. XIV, fig. 1, 62), dislocated by pressure, lie in the axis of the trunk, parallel with the ischia (ib., 63); the vertebral end of the ilium is broader but less thick than the acetabular one; the length of the bone is 4 inches 10 lines, the breadth of the vertebral end is 3 inches 6 lines; the breadth of the acetabular end is 2 inches. The surface here exposed, probably the outer or posterior one, shows a slight concavity on the vertebral expansion, where the bone is smooth; beyond, it becomes longitudinally striate, and rugose or tuberculate near the acetabular extremity; this is thickened and obscurely divided into the rough synchondrosal surface for the ischium, and the corresponding somewhat smaller surface for the ligamentous attachment of the femur.

The ischium (ib., 63) is flat, and of the usual elongate, triangular form; it joins its fellow by its straight inner side having the posterior angle rounded off; the outer, obtuse, non-articular border presents a sigmoid curve, concave near the ilium. The anterior shorter border is emarginate in the middle, where it forms the posterior boundary of the obturator foramen (ib., *o*), the straight articular parts of this side

joining the corresponding parts of the pubis; the outer acetabular angle is produced, and terminally expanded and thickened to form the articular surfaces for the ilium and femur.

The pubis (ib., 64), as in other *Plesiosauri*, is broader and larger than the ischium, with the medial or symphysial margin straight, measuring six and a half inches in extent; the anterior and external free margin is convex; the posterior margin is more deeply excavated than the opposite one of the ischium, forming a greater part of the circumference of the obturator foramen; the angle between the posterior and outer borders is thickened, to contribute the anterior part of the acetabulum. This rough and ill-defined articular surface for the femur is thus formed, as usual, by the three constituents of the pelvis.

The femora (ib., 65) here, as in some other *Plesiosauri*, have the head resting against the ischio-pubic part of the acetabulum, the ilia being placed about an inch further back. The femur, 10 inches in length, is 1 inch 9 lines across the narrowest part of the shaft, and expands to a breadth of 4 inches 9 lines distally; the outer (here the upper) part of the head is produced, and behind it is a longitudinal depression. The surface, for two inches or more from the distal end, is rugose, with longitudinal ridges breaking up into tubercles; both anterior and posterior borders are concave; the latter is the shorter border. The distal border is more regularly convex, and in a greater degree than in the humerus.

There is an interval between the proximal ends of the tibia and fibula, and a wider one between their distal ends, the interosseous space being considerable, as in the forearm. Here, also, the tibia (ib., 66), like its homotype (ib., 54), has a more distal extension. Its length is 3 inches 11 lines, its proximal breadth 2 inches 8 lines. The anterior proximal angle is somewhat produced; the anterior orbital border is slightly concave; the posterior one is more so. The fibula (ib., 67), like the ulna, departs from the ordinary reniform figure by the production of its fibular proximal angle (67′); this is not separated from the rest of the bone in the left leg, but it is so by what appears to be a crack in the right leg, and yet so as to indicate that such crack is in the place of an original epiphysial junction. The length of the fibula, including this process, is 4 inches 4 lines; the length of the concave tibial border of the fibula in a straight line is 2 inches 3 lines. As great a proportion of the exposed surface of the leg bones is rugose as is that in the bones of the forearm. Between the tibia and the tarsal bone supporting the first metatarsal there is a vacant space in both limbs, which, in the right limb, is partially occupied by a tubercle of bone. This we may regard as the beginning of ossification of a fibro-cartilaginous homologue of a naviculare (Tab. XIV, fig. 3, *s*). The homotype of the lunare (*a*) completes, by a free concave part of its border, the distal end of the inter-osseous space. This tarsal (*a*), which we may call " astragalus," articulates with the tibia (66); but to a greater extent and by a more definite straight border, with the fibula (ib., 67); posteriorly with the

calcaneum (*cl*), distally with the two outer bones of the distal row of tarsals. The bone (*cl*) which I have called "calcaneum" is the homotype of the cuneiforme in the carpus, which it resembles in size and shape; it articulates chiefly with the astragalus (*a*) and ecto-cuneiforme (*ec*); it seems to touch the fibula (67) by a small part of its periphery; and in the angle between it and the fibula is wedged an ossicle (*cl'*), answering to the pisiforme in the wrist and to the apophysial part of the calcaneum in the higher Vertebrates. The distal row of tarsals includes but three bones. The first (*ci*), the homotype of the trapezium, I call "ento-cuneiforme;" it articulates with the rudiment of the naviculare (*s*), and supports the metatarsal of the tibial or first toe (*i*). The next bone, "meso-cuneiforme" (*cm*), of larger size, supports the second and part of the third metatarsal, articulates with the ento-cuneiforme (*ci*), and more intimately and largely with the ecto-cuneiforme (*ce*). This (*ce*) is the largest of the three; it supports the fibular half of the base of the middle metatarsal, the whole of the base of the fourth metatarsal, and the tibial side of the base of the fifth metatarsal; it articulates also with the meso-cuneiforme (*cm*), astragalus (*a*), and calcaneum (*cl*); it is plainly the homotype of the os magnum in the wrist. The homotype of the unciforme, if it existed, must have articulated with the posterior or fibular margin of the calcaneum, but it is not present in either limb.

If we regard the largest of the distal tarsal series, supporting the fourth and part of the third and fifth metatarsals, as the "cuboides," we must then consider its obvious homotype in the wrist (*m*) to be the unciforme. The bone here called "meso-cuneiforme" (*cm*), which articulates with both second and third metatarsals, will then be the "ecto-cuneiforme," and the bone (*ci*) will be the two other cuneiform bones connate; in like manner its homotype, called "trapezoides" in the wrist, which has a similar relation to the second and third metacarpals, will be the trapezoid and trapezium connate, but in that case the outermost ossicle (fig. 2, *u*) of the distal part of the carpus would be a supernumerary without a name. I therefore prefer and adopt my first homologies.

The outer surface of the tarsals, except the middle of the calcaneum, is rugose. The first metatarsal (ib., *i*) is 1 inch 9 lines in length; it supports two phalanges; the total length of the toe, including the metatarsal, is 4 inches 9 lines. The length of the second metatarsal is 2 inches 3 lines; three of its phalanges are preserved; it is more distal in position than the first by about 4 lines. The middle metatarsal is 2 inches 5 lines in length; four of its phalanges are preserved. The fourth metatarsal, 4 inches 6 lines in length, has the fibular part of its base more extended, and that margin of the shaft is more concave; four phalanges are preserved, and the length of the digit, including the metatarsal, is 10 inches. The fifth metatarsal is 2 inches 5 lines in length; the tibial angle of its base is truncate, the fibular one is much produced and tuberous; the fibular margin is deeply concave; only one phalanx is preserved.

THE

FOSSIL REPTILIA OF THE LIASSIC FORMATIONS.

CHAPTER II. ORDER—ICHTHYOPTERYGIA, *Owen*.

Genus—ICHTHYOSAURUS, *König*.[1]

A. INTRODUCTION.

REMAINS of the extinct marine Reptiles, now known as *Ichthyosaurs*, have attracted the attention of collectors and describers of organic fossils for nearly two centuries past.

In SCHEUCHZER's 'Querelæ Piscium,' 1708, tab. iii contains figures of the biconcave vertebræ of an *Ichthyosaur* from the Lias of Altdorf, supposed to be a fish. KNORR, also, in his 'Naturgeschichte der Versteinerungen,' vol. ii, represents, in figs. 5—7 of tab. i, vertebræ of the same Reptile, as "*Ichthyospondylen*."

So, likewise, when the attention of more modern palæontologists was awakened to remains of the remarkable subjects of the present Monograph, as in the paper by Sir Everard Home, Bart., F.R.S. ('Philos. Trans.,' 1814), we find such described as "Fossil Remains of an animal more nearly allied to Fishes than any of the other classes of animals."

In this paper, however, as in succeeding ones by the same author, which appeared in the 'Philosophical Transactions' for the years 1816, 1818, 1819, and 1820, the accurate and beautiful engravings of the drawings of the several subjects by WILLIAM CLIFT, F.R.S., enabled contemporary investigators, more capable than Home in determining the true nature and affinities of the fossils, to contribute a durable and rich accession to their science.

In this work the names of CONYBEARE and DE LA BECHE[2] stand pre-eminent, and with them must be associated that of CHARLES KÖNIG, whose appreciation of the affinities of

[1] 'Icones Fossilium Sectiles,' fol., pl. xix, fig. 250, 1825.

[2] "Notice of a Discovery of a new Fossil Animal forming a link between the *Ichthyosaurus* and Crocodile; together with general remarks on the Osteology of the Ichthyosaurus," 'Transactions of the Geological Society,' 4to, vol. v, 1821, p. 559, pls. lx, lxi, lxii.

the animal, the fossil remains of which he figured in the work above cited, is exemplified by the generic name which the extinct Reptile has subsequently borne.[1]

Baron Cuvier amply confirmed the conclusions to which the above-cited authors, and, subsequently, Conybeare[2] arrived, and introduced copies of figures illustrative of their papers in the concluding volume of his great work on 'Fossil Remains.'[3]

In the same year Prof. George Fred. Jaeger recognised fossils as Ichthyosaurian in the Lias of Boll, to one of the plates in whose Work reference will be subsequently made.[4]

Subsequent additions to the history of the genus *Ichthyosaurus* will be found in my 'Report on British Fossil Reptiles,' in the volume of the British Association for the year 1839, 8vo., p. 86.

Before entering upon the details of structure and specific characters I may remark that whenever the antecedent representatives of a class or order may be known, to which an extinct genus is referable, the characters of the genus should be compared with those of its predecessors in such class, rather than with its successors or with existing forms, to gain an insight into its true affinities.[5]

The Labyrinthodont order, prevalent from the Carboniferous to the Triassic formation, manifests the tendency to dermal or peripheral ossifications which was carried out to greater extent in older and lower vertebrate forms. The Ichthyopterygian order, prevalent from the Liassic to the Cretaceous period, continues to show the supplementary 'prosquamosals' (Tabs. XIX and XX, fig. 1, 27′) and 'postorbitals' (ib. ib., 12); and the vertebral centrums retain the biconcave character (Tab. XVIII, fig. 6). The 'foramen parietale' (Tab. XIX, fig. 1, *f*) is common in Carboniferous,[6] Permian, and Triassic Reptiles; and, in some, is larger than in *Ichthyosaurus*,[7] whence it has been continued on to modern *Lacertilia*, but has become obliterated in the Crocodilian order. Both diapophyses and parapophyses[8] appear in Reptilian vertebræ at the same geological period, and are carried on in the Crocodilian modification of the class, but are lost in existing *Lacertilia*.

1 "We have retained in these observations the name Ichthyosaurus, originally applied to this animal by Mr. König, of the British Museum, feeling convinced that on a full and careful review of its whole structure it will not be found to possess analogies sufficiently numerous or strong with the peculiar organisation of Proteus to authorise the change of this appellation into Proteosaurus, as subsequently proposed."—Tom. cit., p. 563, Conybeare and De la Beche.

2 "Additional Notices on the Fossil Genera Ichthyosaurus and Plesiosaurus," 'Trans. of the Geological Society,' 2nd series, vol. i (1824), p. 103.

3 'Recherches sur les Ossemens Fossiles,' 4to, tome 5ème, 2de partie, 1824, p. 447, pl. ii.

4 'De Ichthyosauri sive Proteosauri fossilibus speciminibus in Agro Bollensi repertis,' 4to, 1824.

5 Owen, 'Palæontology,' 8vo, 1860, p. 206.

6 "Ueber *Archegosaurus Dechenii*, Goldf.," von Dr. G. Jäger, 4to, 'München Abhandl.,' Bd. v, 1847, p. 415, tab. xxvi, fig. 1.

7 'Descriptive and Illustrated Catalogue of the Fossil Reptilia of South Africa in the British Museum,' 4to, 1876; *Galesaurus* pl. xviii, fig. 8, 7′; *Petrophryne*, pl. xx, fig. 18, 7′; *Gorgonops*, pl, xxi, fig. 3, 7′; *Dicynodon*, *Ptychognathus*, *Oudenodon*, *Kisticephalus*, pls. lxiv, lxv; *Procolophon*, pl. xxii, figs. 4, 8.

8 Op. cit., *Pareiasaurus*, pl. x, figs. 1, 3, *d*, *p*; *Dicynodon*, pl. lii, fig. 1; pl. liii, fig. 3, *d*.

They are conspicuous Ichthyopterygian characters, and are associated, as far along the spine as they are distinctly developed, with the double-jointed ribs, showing 'capitulum' and 'tuberculum' (Tab. XVII, fig. 2, *a*, *b*). The prezygapophyses of the atlas converge, descend, and aid in forming the anterior cup, which receives a corresponding convex joint-surface of the occipital vertebra; the change from the double condyle of the oldest air-breathing Vertebrates to the single condyle in Triassic Reptilia is retained in the *Ichthyopterygia.* The teeth in this order show a trace of the older Labyrinthodont character in the converging folds of cement penetrating their base,[1] but the alveolar partitions of their native groove are not complete in any part of the tooth-bearing tract. Anchylosis of the tooth-root to the jaw, seen in Mosasauroids and modern Lizards, is not effected in any Ichthyosaur. The teeth retain this freedom, as in Crocodiles, with a similar repeated succession and shedding; as in Crocodiles, also, they are confined to the maxillary, premaxillary, and premandibular ("dentary") bones, but with the ordinal character of much greater length of the premaxillaries than of the maxillaries. The orbits, in *Ichthyopterygia*, are conspicuous for their size; the circle of sclerotic plates usually found fossilised in them exemplifies a primitive vertebral character under a modification continued on in *Chelonia, Lacertilia,* and *Aves.* The nostrils are distinct, and antorbital in position. The limbs are natatory, with many-jointed digits, and these exceed, in some Ichthyosaurian species (Tab. XXVI, fig. 3), five in number. The scapular arch (Tab. XXIV, fig. 4, *Ich. latimanus*, *Ich. communis*, e. g.), includes an episternum (46) and clavicles (58), with a well-developed coracoid (52) and scapula (51), the latter near to, but detached from, the occiput. The hinder part of the vertebral column is as free for natatory work as in Whales; there is no sacrum, but a pair of pelvic fins is constant, and these, usually smaller than the pectoral ones, are supported by iliac, ischial, and pubic bones. The terminal caudals are modified for the support of a tegumentary fin, but are compressed, not depressed, the fin being vertical, not horizontal.

The adaptive modifications of the Ichthyopterygian skeleton, like those of the Cetacean, relate to their medium of existence; they are superinduced, in the one case upon a Reptilian, in the other upon a Mammalian type, and both show analogies to the Vertebrates which the "waters first brought forth." But that the Ichthyopterygians did not breathe by means of gills is shown by the absence of the branchial framework, and by the presence, position, and structure of passages leading from the nostrils to the palate for the course of currents of air on their way to lungs, which were protected and worked by movable thoracic-abdominal costal girdles. Herein these old Sea-reptiles rise higher in structure than some modern cold-blooded air-breathers, such, *e.g.* as Batrachians and Chelonians.

An Ichthyosaur by the shortness, one may say absence, of neck, and equality of

[1] A transverse section of the base of the tooth of an Ichthyosaur gave the first clue to the structure of that of the *Labyrinthodon.* 'Odontography,' 1840, p. 201, pl. lxiv B, fig. 3.

width of the back of the head with the front of the chest, shares with the Whale a resemblance to Fishes, but pushes the likeness closer in the greater number and less length of the vertebræ, and in the indication of the main joints of the backbone being elastic bags filled with fluid, occupying the intervertebral spaces of the biconcave centrums, as in Fishes, Labyrinthodonts, and modern perennibranchiate Batrachians.

Being cold-blooded, and with a small brain needing a much less supply of oxygen for its work, the Ichthyopterygians, like Fishes, had this advantage over Whales, that their stern-propeller could have the form best adapted for a swift straightforward course through the water.[1] The horizontality of the tail-fin of the Whale tribe relates to their need, as large-brained, warm-blooded air-breathers, to have easy and speedy access to atmospheric air. Without the means of displacing a mass of water in the vertical direction by such broad tail-fin the head of the Whale could not be brought with the needed rapidity to the surface for the purpose of breathing. Nevertheless the Cetaceans are restricted to their element as closely as Fishes, and perish almost, if not quite, as soon when cast ashore, whilst the Ichthyosaurs were less limited in regard to medium, and had a power upon dry land which neither of the other aquatic vertebrates enjoy.

That our Sea-lizards occasionally sought the shore is to be inferred from the strong inverted osseous arch supporting their fore fins, spanning across the chest from one shoulder-joint to the other. In structure this arch closely resembles that in a group of aquatic Mammals (*Ornithorhynchus*), which similarly surpass *Cetacea* in having a command of both land and water, although, by their low position in the mammalian class, they have closer alliance to the *Reptilia*.

There is reason to infer, from examples of diminutive Ichthyosaurs fossilized within the abdominal cage of larger ones, and with the snout directed toward, or partly protruding from, the pelvic outlet, that they were ovo-viviparous and, as a rule, uniparous, reptiles.[2] Others may have sought the shore for sleep or copulation, and have been enabled, by reaction of their large and strong fore paddles against the scapular arch, to have crawled or dragged themselves along with the belly resting on the ground.

In outward form an Ichthyosaur (Tab. XXIV, fig. 1) resembled a huge predatory abdominal fish, with a longer tail and smaller or shallower tail-fin; scaleless, moreover, being clothed by a smooth, probably finely wrinkled, skin,[3] something like that of the whale-tribe.

The mouth was wide and the jaws long, armed, as a rule, with numerous pointed and, in some species, trenchant teeth. Masses of comminuted bones and detached ganoid scales

[1] "Note on the Dislocation of the Tail at a certain point observable in the Skeleton of many Ichthyosauri," 'Trans. of the Geological Society,' 2nd series, vol. v, 1838, p. 511, pl. xlii.

[2] As first shown in the specimen of Ichthyosauri from the Lias of Boll, described and figured by GEORGE FRIEDRICH JÄGER, op. cit., tab. i, fig. 4; subsequently noted by QUENSTEDT in specimens in the Tübingen Museum; also by Channing Pearce ('Report of the British Association,' 1874).

[3] "Description of some of the Soft Parts with the Integument of the Hind Fin of the Ichthyosaurus, &c.," 'Trans. of the Geological Society,' 2nd series, vol. vi, 1840, p. 199, pl. xx.

of coeval fishes have been found within the costal cage of the fossil specimens in the situation where the stomach may be judged to have have been. Small, hard, and undigested bodies, containing fish bones and scales, and bearing impressions of the folded surface of the intestinal membrane, have received the name of "coprolites."[1]

Such were the air-breathers which governed the seas of our planet from the Liassic to the Cretaceous period inclusive. At the later epoch the Ichthyopterygians became extinct, and appear to have been superseded by the Mosasaurians. In these the vertebræ have become procœlian; their modified dentition both as to position and attachment is continued on in existing Lizards, but the limbs were fins. The transition, if there was such, is, however, abrupt, and the links are, as yet, unknown which connected the Tertiary cetaceous Zeuglodonts with antecedent whale-like reptiles.

The Cretaceous *Ichthyosaurus campylodon*[2] retains the characters of its order as definitely as they are shown in the species of the Muschelkalk or Lias; and the commencement of this type of Reptile seems to be as abrupt as its close. Much remains to be, and may be, discovered indicating the antecedent forms which linked on more closely the *Ichthyopterygia* with earlier air-breathing vertebrates. But with later ones there is no evidence of transitional alliance; they seem to have passed away under the type of structure which I next proceed to explain as far as study of the fossil remains has made it known to me.

B. Osteology.

a. Bones of the Trunk.—In the vertebræ (Tabs. XVII and XVIII), according to the regions of the column, are to be noted: the centrum (*c*) neurapophyses (*n*), neural spine (*ns*), pleurapophyses (*pl*), hæmapophyses (*h*), hæmal spine (*hs*), zygapophyses (*z*, *z'*), diapophyses (*d*), parapophyses (*p*), and hypapophyses (*hy*). Some of these are autogenous, others exogenous parts.

The centrum is more or less antero-posteriorly compressed (Tab. XVIII, figs. 1 to 7, 9, 13), with concave terminal articular surfaces (ib., fig. 6) not intercommunicating; on each side of the shallow myelonal canal (ib., figs. 2 and 4, *m*) is the deeper, usually triangular, articular surface (*np*) for the neurapophyses (*n*). These, in each vertebra, converge, and, save in the atlas (Tab. XVII, fig. 1, *n*), coalesce at their summits with each other and with the neural spine (ib. figs. 2, 3, 4, *n*, *ns*). In most Fishes the neural arch coalesces with the centrum, as in Cetaceans; its separate state is a saurian, chiefly crocodilian, modification; it is such in the Ichthyosaurs, and adds to the power of inflecting the spine vertically, as in the specimen (Tab. XXV, fig. 2).[3]

[1] Buckland (Dr. Wm.), "Discovery of the Fæces of the Ichthyosaurus," 'Trans. of the Geological Society,' 2nd series, vol. iii, 1835.

[2] Vol. I, p. .

[3] More extreme and abrupt vertical flexures, shown in two specimens in the British Museum, may be

Most of the neurapophyses interlock by means of coadapted zygapophyses (Tab. XVII, fig. 6, *z, z'*). The hæmapophyses are developed beneath the abdominal ribs (ib., fig. 2, *h, h'*,) and beneath the bodies of most of the caudal vertebræ (ib., figs. 4, 5, *h*); they are always distinct from their centrum (*c*), and do not coalesce below with each other, or with a hæmal spine. The hypapophyses remain detached in the first two or three vertebræ (ib. fig. 1, *hy*), and have advanced to the interspace between their own and the antecedent centrum. That of the atlas (Tab. XIX, fig. 5, *hya*) is wedged between it and the basioccipital (*o*); that of the axis (ib., *hyx*) between it and the atlas, and so on (ib., *hy*, 3). Conybeare, who first noticed this structure, describes it as follows :—"We have only seen the inferior piece or body (if it can be so called) of the atlas; and the odontoid process (which in all reptiles forms a distinct piece) of the axis; they very nearly resemble those of the turtle."[1]

In the trunk the centrum of the atlas (Tab. XIX, figs. 2—5, *c a*) is the most modified of that series of vertebral elements. Its fore surface (ib., fig. 2) presents at its upper two thirds a concavity (*c a*), occupying the medial two fourths of its transverse extent, the cavity gradually changing to convexity (*b*) in the lateral fourth. Beneath this smooth concavo-convex articular surface is a rough, flat, triangular surface (*t*), inclining from its upper base backward. The upper joint-surface (*c a*), is for the basioccipital (ib., figs. 1, 2, fig. 5, *o*, in dotted outline), the lower one (*t*), is for the hypapophysis (Fig. 5, *hya*). The hind surface of the atlantal centrum (ib., fig. 4) is flat, and with a few feeble ridges at its peripheral and commonly lower third part. It is rare to find this element unanchylosed with the succeeding centrum (ib., fig. 5, *c x*). The neural surface of the atlantal centrum (ib., fig. 3) is divided equally between the medial quadrate tract (*m*) for the myelon,[2] and the lateral subtriangular depressions (*n p*) for the neurapophyses. The length or fore-and-aft diameter of the atlantal centrum is usually relatively less than in the trunk- or tail-vertebræ of the same individual. The neurapophysial surface bends down upon the side of the centrum, forming a prominence (fig. 5, *d*) on its upper part, representing the diapophysis; beneath this, with a non-articular interval, projects a low obtuse parapophysis (ib., *p*).

The neurapophyses of the atlas (fig. 6, *n*), as far as I have been able to infer from this

posthumous, due to disturbance of the decomposing carcase prior to final burial in the Liassic mud, in and with which the skeleton subsequently became petrified.

[1] 'Trans. Geol. Soc.,' vol. v, 1821, p. 574. The homology of the "odontoid process" as the "centrum of the atlas," and that of the anthropotomical "body of the atlas" with the hypapophysial part of that vertebra, is shown in my "Description of the Atlas, Axis, and Subvertebral Wedge-bones in the Plesiosaurus," 'Annals and Magazine of Natural History,' vol. xx, 1847, p. 217, figs. 1—6.

In 1835 Sir P. de M. Grey Egerton communicated to the Geological Society his discovery of not only Conybeare's "inferior piece of the atlas," but the homotypal parts of the two succeeding vertebræ ('Proceedings of the Society,' vol. ii, No. 41, p. 192), and subsequently gave a detailed description, with figures, of these parts under the name of "subvertebral wedge-bones;" 'Trans. Geol. Soc.,' 2nd series, vol. v, 1836, p. 187, pl. xiv.

[2] 'Spinal marrow,' 'spinal cord,' of 'Anthropotomy.'

commonly mutilated or much disturbed part of the fossil skeletons, were not united together atop, or there developed into an exogenous spine, but retained their distinctness, like their antecedent homotypes the exoccipitals (Tab. XXII, fig. 1, 2). In the best preserved specimen each atlantal neurapophysis is bent back at the middle of its length, the upper compressed portion overlapping the fore part of the base of the neural spine of the axis, as shown in Tab. XIX, fig. 6.

Of the existence of the atlantal pleurapophysis (Tab. XIX, fig. 5, *pl, a*), each being joined by a bifurcate proximal end to the di- and par-apophyses of the centrum, there is better evidence. Such rib was short, directed outward and backward; and is unconnected, distally, with any hæmapophysis (Tab. XVII, fig. 1, *pl*).

The hypapophysis of the atlas (Tab. XIX, fig. 5, *hy, a*, and Tab. XXIII, fig. 2) is an irregular triangular robust ossicle, smooth and convex on its inferior and free surface, with the opposite articular surface divided into three facets. The anterior of these (ib., fig. 2, *a*) is smooth and concave, completing, with the concave part of the atlantal centrum, the cup for the basioccipital ball; an almost flat rough tract (ib., *b*) next below articulates synchondrosaly with the corresponding rough surface of its centrum. Beneath this is a smaller flat roughish surface (ib., *c*), sloping backward from the one above, for articulation with the succeeding hypapophysis. Such are the complex characters of the first trunk-vertebra of *Ichthyosaurus*.

The centrum of the second vertebra (Tab. XIX, fig. 5, *cx*, and Tab. XXII, figs. 3, 4, 5), has a flattened, roughish, anterior surface (fig. 4), like the posterior one of the first vertebra, with which it sooner or later coalesces. The hind surface of the axis-centrum (fig. 5) is more deeply and entirely concave, with a sharpish circumferential margin. On the upper surface of the centrum (fig. 3) the myelonal surface (*m*) is similar in size and shape to that of the atlas, but is shallower. The neurapophysial surfaces (*n, n*) are less excavated, and the diapophysial productions (fig. 4, *d, d*) upon the sides of the centrum are more prominent, better defined as processes. The same may be said of the parapophyses (ib., *p, p*), which project close to the fore border of the side surface and show a more distinct facet for the head of the axial rib than do those of the atlas. The length of this rib is a little more than the vertical diameter of the centrum. The lateral surfaces of the centrum of the axis-vertebra are antero-posteriorly concave, of greater extent behind the rib-processes; vertically they describe a convex curve converging from each side to an inferior medial ridge. This ridge is interrupted, anteriorly, as if that end had been obliquely cut off, forming a roughish subconcave facet for the hind half of the base of the second or axial hypapophysis (Tab. XIX, fig. 5, *hy, x*.) This element is barely half the size of the one in front, is conical, the apex downward; the base is divided into the surfaces respectively joined to the contiguous hypapophysial facets of the atlas and axis. The neurapophyses converge as they rise and coalesce to form the base of a neural spine (ib., fig. 6, *n s*), the antero-posterior extent of which equals the height—a proportion which distinguishes that part of the second vertebra. Postzyga-

pophyses (ib., *z*) are developed from the base of the spine which overlap and articulate with the prezygapophyses (*z*) of the third cervical vertebra.

Thus, at the fore part of the vertebral column, the neural arch presents the three following modifications:—In the atlas the neurapophyses remain distinct and develop neither post-zygapophyses nor neural spine; in the axis they coalesce, develop the post-zygapophyses and a lofty spine, broader than those in the succeeding vertebræ; the neural arch of the third cervical develops both pre- and post-zygapophyses (ib., fig. 6, *z*, *z*) and a neural spine (*ns*), subcompressed like that of the axis, but narrower antero-posteriorly: in both vertebræ the neural spine inclines rather backward.

The above descriptions and figures are from an immature specimen of *Ichthyosaurus longifrons.*

In the vertebræ along about a third or more of the trunk, the neurapophysial surface is continued on to the diapophysial process (Tab. XVIII, figs. 1—3, *np*, *d*). This process next becomes distinct (ib., fig. 4, *d*); and, as the parapophysis continues to be developed, the presence of the pair of tubercles, *d*, *p*, near the fore margin of the side of the centrum characterises that part as far as the fortieth or forty-fifth vertebra in *Ichthyosaurus communis.* In this course both processes gradually descend (ib., figs. 5, 7, *d*, *p*.), but the diapophysis more rapidly, until it coalesces with the parapophysis, forming therewith an oblique ridge or rising. In the caudal vertebræ the ridge gradually contracts to a rounded tubercle (ib., figs. 9, 11, *d*, *p*.), and finally disappears at about the eightieth vertebra (ib., fig. 13). At this part of the column, in *Ich. communis,* the abrupt bend or dislocation of the caudal series commonly occurs; and here three or four of the centrums become more compressed than either those that precede or those that follow them, and their lateral margins are raised, as if by forcible compression.

The neurapophysial facets become detached from the diapophyses (*d*) by contracting in breadth, and take the form of narrow longitudinal grooves (ib., fig. 5, *np*), bounding laterally the myelonal surface (*m*). This surface sinks a little deeper into the centrum as the vertebræ recede in position, and in the caudal region it contracts both vertically and laterally, until it loses definition in the extreme vertebræ.

The articular bases of the neurapophyses undergo corresponding modifications; the joint-surface is subtriangular, somewhat protuberant in the anterior vertebræ; but, after the diapophysis or rib-surface gets independent, that for the neurapophysis becomes longitudinal, narrow, and grooved. The neurapophysis rises, with a slight receding from the vertical position, for a height usually equalling its fore-and-aft breadth; it develops a short prezygapophysis and inclines backward, with a postzygapophysial surface at its under and hinder part. The pair of neurapophyses having then coalesced send upward and slightly backward a subquadrate compressed neural spine, usually twice the height of the the subzygapophysial part or pedicle (Tab. XVII, fig. 6, *n*) of the neurapophysis, and with gradually augmenting height and antero-posterior breadth as far as the midpart of the trunk. Towards the hind part the spines begin to lose height, but not breadth, until

they enter the caudal region, when they gradually decrease in all dimensions, and disappear at or near the bend of the tail. Feeble emarginations at the fore and hind part of the pedicle form or bound the nerve-outlets.

The contour of the centrum (Tab. XVIII) varies with the number and position of its lateral processes. At the fore part of the column it is more or less shield-shaped (fig. 3), with the angles of the upper border rounded off; at the hind part, where the rib-processes have descended (fig. 8) or have coalesced (fig. 11, *dp*), the base is below and the apex truncate for the neural arch; further on, where those processes have disappeared, the contour becomes ellipsoid or elliptic, with the long axis vertical.

The centrum is always short in proportion to its breadth and depth, but this varies in different species; beyond the atlas and axis it is always biconcave (ib., fig. 6), but the contour of the concavity varies specifically. In some the sinking begins at the periphery; in others in a feebler degree there; in others a slight and narrow marginal convexity (fig. 3) precedes or leads to the central concavity; in others, again (fig. 8), a peripheral portion of the joint-surface is flat before it sinks into the central hollow; in exceptional instances, the fore and hind concavities blend at a small central perforation, as they do in the Triassic 'Tretospondilia' of the Cape.[1]

The pleurapophyses (dorsal ribs, Tab. XVII, fig. 2, *pl*) are developed, as free movable elements, over a larger proportion of the vertebral column than in most other four-limbed *Reptilia*, extinct or existing (Tab. XXIV, fig. 1). They commence at the foremost segment as shown in the description of the 'atlas' (Tab. XIX, fig. 5, *pl*), gain slightly in length on the axis, in a greater degree on the third vertebra, and acquire their extreme length between the tenth and thirtieth (Tab. XVII, fig. 2, *pl*, and Tab. XXIV, fig. 1); beyond this they shorten, but continue as free elements, though short and straight (Tab. XVII, fig. 4), along a great part of the caudal region; their existence, as such, being attested in detached centrums by the single sessile process (Tab. XVIII, figs. 9—11, *dp*) on each side: with the disappearance of the di-parapophysis the ribs cease. All the ribs are comparatively slender, commonly subcylindrical; the longer ones, or those of the trunk, are longitudinally grooved on their outer surface (Tab. XVII, fig. 7), as if each rib consisted of two confluent more slender ones.[2] This structure is not common to all the species. A transverse section which I made exposed a small central cavity.

The hæmal or costal arch is complete along the major part of the trunk. Here the hæmapophyses are each in two partially overlapping pieces (ib., fig. 2, *h*, *h'*); they are more slender than the pleurapophyses.[3] The median piece (hæmal spine, *hs*) is transversely extended, symmetrical, slightly produced at its thickest midpart, forward and backward, but more extended laterally, there becoming slender and diminishing to a point. A similar slender piece, pointed at both ends (*h'*), is spliced as it were, to the fore part of each

[1] 'Quarterly Journal of the Geological Society,' vol. xxxii, p. 43 (1875).

[2] Clift, 'Phil. Trans.,' MDCCCXIV, pl. xix (1814, *Ichthyosaurus platyodon*).

[3] Ib., 'Phil. Trans.,' MDCCCXIX, pl. xiv (1819, *Ichthyosaurus communis*).

lateral production of the medial piece. A second styliform hæmapophysis (*h*) is similarly adapted to the fore part of the foregoing style; but as it approaches its pleurapophysis it is slightly thickened, and is joined by a truncate end to that of the pleurapophysis (*pl*). Of the five bones which thus constitute the hæmapophysial part of the thoracic-abdominal hæmal arch, the two on each side I regard as a divided hæmapophysis, and the transversely extended medial piece as the hæmal spine, or abdominal "sterneber." A small but strong triradiate hæmal spine ("episternum") closes the dislocated occipital hæmal arch formed by the modified pleurapophyses ("scapulæ") and hæmapophyses ("clavicles").

In the caudal region the centrum, save at the terminal pinnigerous part, shows a small tubercle at or near each of the four angles of the quadrilateral space (Tab. XVIII, figs. 9, 12), forming the lower surface, the anterior tubercles (*hy, hy*) being the largest. Each has an articular surface, and the contiguous ones of coadapted centrums give attachment to the base of a short and slightly bent hæmapophysis. These elements, of the same pair, converge as they descend, but do not coalesce to form a "chevron-bone," nor is a hæmal spine developed. These inferior or hæmal arches cease on the terminal twenty or more vertebræ; in most of these the centrum is subcompressed, especially where the seeming fracture or abrupt bend (Tab. XXII, fig. 8) takes place.

b. Bones of the Head.—The results of my studies in the craniology of the species of *Ichthyosaurus*, subsequent to the 'Report on British Fossil Reptiles' of 1839, were given in the 'Hunterian Lectures,' at the Royal College of Surgeons, London, 1855; and in those delivered at the Museum of Practical Geology, Jermyn Street, in 1858.[1] I have found but little to add or alter in the course of subsequent researches in the preparation of the present Chapter.

The general form of the skull of the typical species, *Ichthyosaurus communis* (Tab. XXIV, fig. 1), as in *Ich. breviceps*, *Ich. intermedius*, *Ich. lonchiodon*, and *Ich. platyodon*,[2] resembles that of the Cetaceous Dolphins (*Delphinus tursio* and *Delphinus delphis*). In *Ich. acutirostris* (ib., fig. 2) the beak is produced to the shape of that of a gigantic stork, while *Ichthyosaurus tenuirostris* and *Ich. longirostris* (ib., fig. 3) rival or surpass the *Delphinus* (*Inia*) *gangeticus* in the length and slenderness of the jaws.

The main difference in the Sea-reptiles lies in the restricted capacity of the brain-case, the seeming expanse of the cranium being due to the great depth and breadth of the post-orbital part of the zygomatic arches or outer walls of the temporal fossæ. A more essential departure from the warm-blooded Vertebrates is the persistent individuality of those cranial elements which, though primitively distinct, become blended into single bones in

[1] Notes of these Lectures were published in the 'Annals and Magazine of Natural History,' 3rd series, vol. i, 1858, p. 388 *et seq.*

[2] See Clift's excellent figure in 'Philos. Trans.,' MDCCCXIV, pl. xvii.

the higher and later developed forms. The Ichthyosaurs further differ from the marine mammals in the great extent of the premaxillary and the small size of the maxillary bones, in the great capacity of the orbits and the circle of sclerotic plates lodged therein, and, finally, in the antorbital vacuities serving as external bony nostrils.

The occipital region of the skull (Tab. XXII, fig. 1) is of great breadth and of moderate height. In its formation there enter not only the basi-, ex-, super-, and par-occipitals, but also part of the parietals, mastoids, tympanics, zygomatics, prosquamosals, and pterygoids.

The chief feature is the large proportional size of the basi-occipital (ib., 1), the outer surface of which is divided into an articular (Tab. XXI, fig. 1, 1′) and non-articular part (ib., 1). The articular portion is in the form of a hemispheric, convex condyle, in some species showing a subcentral depression, but deriving no contribution from the exoccipitals, and divided from the 'foramen magnum' by a narrow, upper non-articular tract; the lateral tract gains breadth as it descends along the sides of the condyle, below which it shows an extent of two thirds the diameter of the condyle; but this part of the basioccipital, in extending forward, deviates little from the perpendicular, and belongs rather to the hinder than the under surface of the cranium. The upper non-articular part of the basi-occipital, dividing, in the specimen under description, the condyle from the foramen magnum, is one eighth the diameter of the condyle; then come the depressions for the sutural joints with the exoccipitals, a mere crest dividing them. The exoccipitals (Tab. XXII, fig. 1, 2, 2) are small and reniform; their bases almost meet above the basi-occipital; their obtuse summits are divided by the base of the super-occipital (3), which contributes about a fourth part of the circumference of the foramen magnum (*f*).

The fore part of the basioccipital presents, in some species, a slight notch or groove, as if for the outlet of an Eustachian canal. This canal, in Crocodiles, traverses the basi-sphenoid, close to its suture with the basioccipital.

The basioccipital articulates, below or in front, with the basisphenoid (Tab. XXI, fig. 1, 5) laterally with the paroccipitals (Tab. XXII, fig. 1, 4); but between these and the basisphenoid it joins the mesially inclined hinder end of the pterygoids (ib., 24). The apex of the superoccipital (3) is wedged into the interspace of the hinder bifurcation of the parietal bones (7′), which it underlaps and partly supports; its base forms the upper border of the foramen magnum. The paroccipitals (ib., 4, 4), broadest where they join the basioccipital, contract as they extend outward into a strong triedral bar, which abuts against the tympanic (28), at the interval between the mastoid (8) and pterygoid (24).

The centrum (1), neurapophyses (2), neural spine (3), and parapophyses (4) of the hindmost cranial vertebra are instructively demonstrated by the Ichthyosaurian condition of the 'occipital bone' of Anthropotomy.

The basisphenoid (Tab. XXI, fig. 1, 5) presents, on its under and outer surface, the form of an irregular, subquadrate plate, narrowest behind, where it joins the basioccipital, expanding as it advances, the anterior border presenting a rough, sutural, notched

surface, at its middle third, for the presphenoid (9), and a smooth emargination on each side forming the hind border of the sphenopterygoid or 'interpterygoid' vacuities (*s*, *s*).[1] The hinder half of the under surface of the basisphenoid presents shallow rough depressions and feeble risings for muscular attachments, and, like the basioccipital, it is imperforate. Of the alisphenoids I have been unable to determine more than their presence and their small size. The side walls of the brain-case proper seem to have been mainly cartilaginous.

The parietals (7) in most Ichthyosaurian skulls retain their median (sagittal) suture (Tab. XIX, fig. 1, 7), which usually opens out anteriorly to form the hind end of the 'foramen parietale' or fronto-parietal fontanelle[2] (*f*), the chief part, or whole, of which is bounded by the frontals (11).

The upper surface of the parietals seems, by reason of the aspect of the occipital portion, to be divided by a ridge (*r*) extending from the mastoids (8″), and continued upon the parietals to their mid-suture, into an anterior (7) and posterior (7′) surface. This mastoparietal ridge (8″ *r*) properly bounds, above, the occipital surface, to which the parietals thus contribute about a fifth part of their length above the superoccipital bone (Tab. XXII, fig. 1, 7′). Anterior to this ridge each parietal slopes to the temporal fossa (Tab. XIX, fig. 1, T), the parietal surface being divided by a low longitudinal rising continued forward from a posterior convexity into two facets, both of which are concave across. The dividing ridge is overlapped by a postero-mesial angle of the postfrontal (12), between which and the frontal a narrow forward continuation (7″) of the parietal is exposed, which overlaps the hind part of the frontal. The margins of the sagittal suture usually rise into a low ridge, which is continued upon the occipital part (7′) of the parietal. Of this part (Tab. XXII, fig. 1, 7′) the surface on each side of the mesial ridge is feebly concave, almost flat, laterally overlapped by the mastoids (8″); it seems to rest upon, without sutural junction with, the superoccipital (3). The postero-lateral extension of the parietal (ib., fig. 1, 7*x*) curves down beneath the mastoid (8) to within a third part of the lower end of that bone, contributing therewith to the upper and lateral parts of the broad occipital surface.

The mastoid (8, 8′, 8″) is a large and strong triradiate bone, the rays inclining forward from the outwardly obtuse centre or body forming the prominence at each postero-lateral angle of the skull. The upper and inner ray or branch (Tab. XIX, fig. 1, 8″) is three-sided, one facet looking upward, a second backward, the third forward and outward, contributing, with the parietal, to the outer and hinder wall of the temporal fossa (T). The angle at which the anterior joins the superior facet is continued forward upon the ridge (8″*r*), dividing the hinder and upper facets of the parietal bone. The lower mastoid branch

[1] 'Anatomy of Vertebrates,' vol. i, p. 157, fig. 98, *D*, *s*.

[2] "This foramen, or 'fontanelle,' is common in the Triassic *Reptilia*. It is described and figured in *Galesaurus*, *Petrophryne*, *Dicynodon*, *Ptychognathus*, *Oudenodon*, *Kisticephalus*, and *Procolophon*; in the latter it is large. It is wholly 'parietal' in *Kisticephalus* and *Ptychognathus*, in which it is placed far back."—'Descriptive and Illustrated Catalogue of the Fossil Reptilia of South Africa in the British Museum,' 4to, 1876.

(Tab. XXII, fig. 1, 8) is a broader plate, smooth, and almost flat externally, forming the upper sides of the occipital region, articulating outwardly with the prosquamosal (27′) and tympanic (28), and below with the pointed process of the pterygoid (24), wedged between the mastoid and tympanic, and here overlapped by the paroccipital (4) in its way to abut against the tympanic. The outer branch of the mastoid, smooth and subconvex outwardly (Tab. XX, fig. 1, 8′), extends forward to form the hinder half of the upper zygoma, overlapped by the post-frontal (Tabs. XIX, XX, figs. 1, 12), and articulated along its lower border with the broad sclerodermal plate ('prosquamosal,' 27′)[1] occupying the interval between the upper and lower zygomata.

The tympanic is abruptly divided into an upper auditory or proper tympanic portion (Tab. XXII, fig. 1, 28) and a lower articular portion (ib., 28′). The former is a narrow, subcompressed, outwardly subconvex, bony piece, and is wedged between the mastoid (8) and prosquamosal (27′); its hind or mesial border extends from the mastoid junction to articulate with the pterygoid (24); the outer or lateral border is smoothly rounded and concave, forming more than the hinder half of the auditory meatus (*m*). The suddenly expanded, thick, articular portion (28′) joins the pterygoid (24) mesially and the zygomatic (27) laterally, then descends obliquely backward, for an extent equal to the auditory portion, to thicken and terminate in the surface for the articular element of the mandible. This surface is obliquely suboval, convex from before backward, slightly concave transversely at its fore part.

The hyoid, or hæmal arch of the second cranial segment, is represented by a basihyal and by a pair of rib-like bones (Tab. XXI, fig. 3, 38), homologous with the thyrohyals in the Crocodiles, which elements they resemble in their small relative size, but are of more simple structure. Each is feebly and regularly bent, the convexity (in the petrified skull) turned towards each other, converging forward to their junction with the small flattened basihyal, which junction seems to have been by much ligamentous tissue. I noted in a fossil cranium of a full-sized *Ichthyosaurus communis* that the hind ends were $4\frac{3}{4}$ inches apart while the fore ends were but $1\frac{1}{2}$ inch apart. The total length of the bone was 4 inches 2 lines; the breadth of the hind end was $\frac{1}{2}$ an inch, that of the mid-part 5 lines. In the *Ich. lonchiodon* (Tab. XXVII, fig. 5) each thyrohyal is a fifth part the length of the mandible. The stylohyals appear to have retained their fibro-cartilaginous or cartilaginous tissue, and have consequently disappeared.

The presphenoid (Tab. XXI, fig. 1, 9) is a long, slender, trihedral bone, broadest where it joins, and commonly coalesces with, the basisphenoid (5) and, along the narrower part, with the two lower sides, converging to a median obtuse angle. It divides the long and narrow, pear-shaped interpterygoid vacuities (*s, s*).

Of the orbitosphenoids I have no exact knowledge; they may not have been

[1] This osseous plate is described in my "Report on British Fossil Reptiles," 'Reports of British Association,' 1839, 8vo, p. 9, as the "squamous element of the temporal bone;" it is analogous therewith but not homologous.

ossified, there is no trace or sign of the lacertian columellar bone near that part of the cranium.

The frontals, or midfrontals (Tab. XXIII, fig. 1, 11), are small, transversely convex in greater or less degree according to the species, curving in toward the mid-suture in most, and bending outward and downward to the obtuse angle intervening between the nasal (15) and the postfrontals (12). At the hind end of the frontal suture each border curves outwardly to contribute their large share to the 'foramen parietale,' then converging and, in some species (*Ich. latifrons*, Tab. XXIII), wholly encompassing it; here, also, as in some other species, the midfrontals distinctly join the postfrontals. In all the species the hind border joins the parietal (7), the fore border the nasal (15). The midfrontals are widely separated from the orbits by the postfrontals and nasals. I have not had clear evidence of their touching the prefrontals, or of the presence of distinct superorbitals. In *Ichthyosaurus latifrons* (ib., fig. 1) the frontal suture becomes obliterated, and the bone (11) is convex lengthwise as well as across.

The postfrontals (ib., and Tab. XIX, fig. 1, 12) exceed the midfrontals in size. Each extends from a mesial angle outwards, expanding horizontally, and inclining to form its share of the superorbital border; thence the postfrontal is continued backward, bending down to join the postorbital (12′) and prosquamosal (27′), and contracting to a notched and pointed end, which receives and overlaps the fore end of the zygomatic ray of the mastoid (Tab. XX, fig. 1, 8′). The similarity of character in the postfrontal (12) and mastoid (8) is worthy of note in regard to their general homology as cranial diapophyses.

The hæmal or pleurapophysial arch of the third or frontal segment of the cranium is modified to constitute the lower jaw.

In the mandible of *Ichthyosaurus* the articular element (Tab. XXII, fig. 2, 29)[1] is scantly visible in an outside view, being covered by the largely developed and backwardly extended surangular[2] (ib. 30). With this the angular coextends or slightly surpasses behind (ib., 31).[3]

Of both elements the outwardly exposed surfaces (Tab. XX, fig. 2), as they advance, gradually diminish to a point; the surangular (30), in *Ichthyosaurus communis*, disappearing between the dentary (33)[4] and splenial (32),[5] in advance of the hinder half of the ramus; the angular (31) terminates between the surangular (30) and splenial (32), as far behind the fore half of the ramus. The hind part of the outer surface of the surangular shows a triangular, almost flat, but feebly concave surface, finely sculptured with linear impressions, converging forwards to the apex of the triangle, and indicative of a muscular insertion. In advance of this part the surface is smooth and feebly convex, gaining in depth by the convex curve of the lower border, and a similar one at the upper border, which

[1] Cuvier, 'Oss. Foss.,' v, pt. ii, p. 272, pl. xvi, figs. 4 and 5 (*Varanus*), *d* ('articulaire').

[2] Ib., ib., 'surangulaire,' *f*.

[3] Ib., ib., 'angulaire,' *e*.

[4] Ib., ib., (*Varanus*), 'os dentaire,' *a*.

[5] Ib., ib., 'operculaire,' *b*.

simulates a coronoid process. Opposite, or beneath the slender lower boundary of the orbit, the surangular is overlapped by the hinder-jointed end of the dentary (33). An oblique canal opens forward below the coronoid rising, beneath the hind border of the orbit, whence extends forward a channel, becoming shallow and ending beneath the overlapping point of the dentary. The angular (31) gradually diminishes in breadth or depth as it extends forward.

From such views as I have been able to obtain of the inner surface of the mandibular ramus, the articular element (Tab. XXII, fig. 2, 29), after developing the concavo-convex broad surface for the tympanic, seems to be continued forward as a thinner, deeper plate, corresponding to the 'complementaire' of Cuvier.[1] It, however, develops no coronoid process in Ichthyopterygians, but in some specimens seems to be a detached scale (ib., figs. 2 and 3, 30′), simply applied to the inner surface of the ramus over the line of junction of the surangular and angular elements touching or joining anteriorly the hind end of the splenial.

This element (Tab. XX, fig. 2, 32; Tab. XXII, figs. 3—6, 32) begins behind by a point between the surangular and angular, gains breadth as it advances to become applied to the inner side of the dentary, which it also underlaps and strengthens usually to within the anterior fourth part of the length of that element. The splenial in *Ich. communis* contributes a small part of the outer side of the jaw beneath the anterior pointed end of the surangular.

There are no other indications of lack of outer surface of the ramus than the neurovascular foramen and groove of the surangular and smaller irregular foramina in the dentary.

This important element (Tab. XX, fig. 2, 33; Tab. XXII, figs. 4—7, 33) is the longest, if not largest, constituent of the composite mandibular ramus; it seems not to have carried in any species its symphysial articulation with its fellow to actual confluence. It affords for the lodgment of the mandibular teeth at the hinder half or more of that series only the outer wall and more or less of the floor of a broad and shallow alveolar channel, the inner wall being here supplied by the splenial element (Tab. XXII, figs. 4 and 5, 32). As the dentary advances it supplants the splenial by developing an inner wall, which finally rises so as to exceed in height the outer one (ib., figs. 6 and 7, 33). The inner surface of the outer wall of the dentigerous groove shows feeble vertical ridges, indicative of alveolar compartments, like those seen along the hinder terminal part of the same channel in *Crocodilia*.[2]

On the outer surface of the dentary, a little below the alveolar border, a series of vascular foramina and grooves leading thence forward is seen in most species of Ichthyosaurs; in a few species the same surface is indented by a narrow longitudinal furrow.

[1] Loc. cit., p. 272, *c*.

[2] 'Descriptive Catalogue of the Osteological Series contained in the Museum of the Royal College of Surgeons of England,' 4to, 1853, vol. i, p. 167, Specimen No. 765.

The longitudinal central vacuity of the mandible or interspace between its several constituents is considerable, as is shown in CLIFT's figure of a transverse section of a ramus.[1]

After comparison of the foregoing structure with the homologous bone in *Reptilia*, I may remark that the mandible of *Ichthyosaurus* differs from that in *Lacertilia* in the minor relative size and backward extension of the articular (29);[2] it resembles more the *Crocodilia* in the major relative size of the angular (31), but exceeds in its proportion and its position as forming the angle of the jaw, though it is less produced backward. It differs from both the Crocodilian and Lacertian jaws in the larger relative size of the surangular, which extends backward so as almost to conceal the articular from outward view. It resembles the *Crocodilia* in the absence of any coronoid process from a complementary element; also in the larger relative size and length of the 'splenial;' in this character the Monitors depart less than do the Iguanas from the Ichthyosaurs. In the dentary element *Ichthyosaurus* shows the important affinity to *Lacertilia* in the dental groove, devoid of alveolar partitions; but in the rudimentary indication of these there is a resemblance, as before remarked, to the short non-alveolar tract at the back of the dental series in some *Crocodilia*. The mandible of *Ichthyosaurus* notably differs from that of Crocodiles, and resembles that of Lizards, in the absence of the vacuity between the angular, surangular, and coronal elements, and in the presence of the longitudinal series of neurovascular foramina or outlets along the outer side of the dentary element.

In the greater extent of the mandibular symphysis *Ichthyosaurus* differs from both Crocodiles and Lizards; in these, it is limited to a small part of the dentary element, but in *Ichthyosaurus* it includes both dentaries and splenials, and the 'symphysis dentarii' (Tab. XXI, fig. 2, 33′) is to be noted together with the 'symphysis splenii' (ib. ib., 32′) in the discrimination of species. Thus, the latter is longer than the dentary symphysis in *Ich. intermedius*, but is shorter in *Ich. communis*, and, relatively, much shorter in *Ich. tenuirostris* (ib., fig. 3), *Ich. longirostris* (ib., fig. 2), and other long and slender-jawed kinds.

The vomerine bones are narrow, longitudinal, vertically disposed plates, with their lower margins rarely visible at the interspace of the palatines and pterygoids.

The prefrontal (Tab. XX, fig. 1, 14) I, as yet, know only by its external or facial part. This is a narrow, moderately long, bony tract, extending from the postfrontal to near the nostril (*n*), there receiving the upper angle of the lacrymal (73) in a notch, the upper branch of which notch is wedged between the lacrymal and nasal, (15); the lower boundary is bent inwards to form part of that of the orbit. The extensive upper and inner border of the prefrontal articulates with the nasal, the short hinder border with the postfrontal.

The position and relations of the prefrontal in *Ichthyosaurus*, as in some Fishes,

[1] 'Philos. Trans,' 1820, pl. xvi. See also Pl. XXII, figs. 4 and 5, of the present Chapter.

[2] CUVIER, tom. cit., pl. xvi, figs. 4, 8, 13, *d*.

instructively illustrate its general homology as an element of a cranial segment distinct from that to which the frontal belongs, of which bone it has been regarded as a mere dismemberment. As the neurapophyses of the nasal segment they lend, in *Ichthyosaurus*, a large share of their longitudinal extent to the support of their neural spine, the nasal bone. The large size of both pre- and postfrontals relates to that of the eye and of the cavity destined to contain it in the *Ichthyosaurus*.

The nasals (Tabs. XIX, XXIII, figs. 1, 15) are the longest and largest bones of the cranium proper, but contribute only a small part to the side face; each sends a pointed process backward into a corresponding notch of the frontal which it partially overlaps. The apex of the process is in contiguity with the parietal; a notch on each side the base of the process receives the anterior part of the frontal; the angle of the outer notch touches the postfrontal. By its outer border the nasal unites with prefrontal, lacrymal, and premaxillary (22). The latter overlaps and conceals the naso-maxillary suture in the species in which such may be traced. The upper horizontal parts of the nasals gradually diminish to a point between the nasal portions of the premaxillaries. The exposed extension of the nasals terminates, in *Ich. tenuirostris*, about as far in advance of the nostrils as the fore-boundary of these is in advance of the orbits.

The palatines (Tab. XXI, fig. 1, 20) are long, slender bones, commencing behind at the anterior notch between the pterygoid (24) and ectopterygoid (25), forming, as each advances, the mesial boundary of the small palato-naris (*p n*). The palatine then extends forward, joining mesially the pterygoid, until this diminishes to a point, when the palatines come into contact or near contact with each other at the midline of the palate. Externally the palatine unites with the maxillary (21), but the suture is hidden by the underlapping extension of the palatal process of the premaxillary (22), which reaches to the palato-naris.

The maxillary (Tab. XX, fig. 1, 21) begins behind, parallel with the anterior third of the orbit, from which it is divided by the slender fore part of the malar (26). As it advances the maxillary expands into a facial, an alveolar, and a palatal plate, articulating mesially with the ectopterygoid (Tab. XXI, fig. 1, 25), and, in advance of the palato-naris, with the premaxillary (22). The palato-alveolar part of the maxillary is divided from the facial part by the outer alveolar wall. The facial part (Tab. XX, fig. 1, 21), coming into view beneath the fore part of the malar (26), expands slightly to unite with the lacrymal (13), and, in the species affording the subject of fig. 1, Tab. XX, it contributes the middle third of the lower border of the nostril; but, as a rule, it is separated therefrom by the junction of the lacrymal (73) with the premaxillary (22), as in fig. 2. In advance of this the maxillary is overlapped by the premaxillary, which conceals it from view at about the fifteenth tooth, counting forward, in *Ichthyosaurus tenuirostris*. In no species does it support more than about one third of the series of teeth on its own side of the upper jaw.

The premaxillary (Tabs. XIX—XXI, XXV, figs. 1, 22) is characterised by its great

relative length. Its facial part begins behind by an expanded bifurcation bounding anteriorly the nostril; in advance of which the bone gradually expands, overlapping the nasal and maxillary, descending to the alveolar border to form the major part of the upper jaw, and narrowing to the end. The palatal portion (Tab. XXI, fig. 1, 22), long and narrow, is continued backward between the maxillary and palatine to terminate in a point penetrating the palato-naris (*p n*).

The pterygoid (Tabs. XXI, XXII, fig. 1, 24) is also a bone of considerable size, especially length. It begins behind by a triradiate expansion; the outer short subquadrate branch abuts against the tympanic (28); the upper narrower pointed ray is wedged between the paroccipital (4), mastoid (8), and tympanic (28); the inner and longest branch is broad, wedged between the paroccipital and basisphenoid, reaching with its blunt-pointed end the basioccipital. In advance of this triradiate expanse the pterygoid contracts, presenting a concave inner border, articulating with the side of the basisphenoid (5), and a more concave outer border, which forms the inner one of the cavity which was occupied by the gristly petrosal. As it continues to advance, the pterygoid again expands, its outer border forming an angular process, to the fore part of which the ectopterygoid (25) unites; the pterygoid then extends forward and gradually inward (mesiad), decreasing in breadth, and is continued as a long and narrow strip of bone in contiguity with its fellow, bounding anteriorly the long interpterygoid vacuity (*s*), articulating outwardly for one half of its extent with the ectopterygoid, and for the other half with the palatine.

The ectopterygoid (Tab. XXI, fig. 1, 25) is an elongate plate of bone, though less than half the length of the pterygoid; its rounded hind end and much of its mesial margin articulate with the pterygoid, the rest with the palatine, with which it combines to form the hind boundary of the palato-naris (*p n*). The outer margin contributes to bound the pterygomaxillary vacuity (*y*) posterior to its junction with the maxillary, along which it extends to opposite the fifth upper tooth or thereabouts, counting forwards, and there terminates in a point.

The malar (Tab. XX, fig. 1, 26) is a long and slender, moderately bent bar of bone, commencing anteriorly in a point wedged between the lacrymal and maxillary, thence receding to form the lower boundary of the orbit, and expanding to be partially overlapped by the postorbital bone (12′), behind which it terminates as a wedge between that bone and the zygomatic.

This bone (ib., 27) is subquadrate, its vertical equalling its longitudinal extent; the angles are more or less produced. The upper anterior one is wedged between the prosquamosal (27′) and postorbital (12x) bones; the lower anterior one underlaps the end of the malar; the front border articulates with both malar and postorbital, the upper border with the prosquamosal; the hind border is rounded and concave, forming the fore part of the 'meatus auditorius externus' (Tab. XXII, fig. 1, *m*); the hinder half of the under surface of the zygomatic expands, and is slightly excavated to articulate with the outer and upper part of the expanded articular end of the tympanic (28′).

The lacrymal (Tab. XX, fig. 1, 73) forms the lower two thirds of the anterior border of the orbit; it sends off from the middle and inner part of this border a short process protecting the lacrymal orifice. The bone contracts vertically as it approaches the nostril, of which it forms the hind concave border. The upper part of the lacrymal sends a process which fits into a notch of the prefrontal (14), anterior to which it joins both the prefrontal and the nasal. Anteriorly, it unites in some species with the maxillary (ib., fig. 1), in most with both maxillary and premaxillary (ib., fig. 2); its lower and longest margin articulates with the maxillary and malar.

The two supplemental skull-bones in Ichthyosaurs, which have no homologues in Crocodiles, are the postorbital (12 *x*,)[1] and prosquamosal (27′);[2] both are present in Labyrinthodonts. The postorbital is the homologue of the lower division of the post-frontal in those Lacertians (*e. g. Iguana, Tejus, Ophisaurus, Anguis*) in which that bone is said to be divided. The postorbital most resembles a dismemberment of an ascending process of the malar; its lower end overlaps and joins by squamous suture the hind end of the malar; whence it slightly expands, rising to the middle of the back of the orbit, thence, gradually contracting as it curves upward and forward, it articulates with the prosquamosal (27′) and postfrontal (12).

Were the prosquamosal (27′) connate with the zygomatic (27) as in *Chelone*, the resemblance to those parts of the Mammalian 'temporal bone' would be close, save that the squamous portion would be removed from the inner to the outer wall of the temporal fossa. The prosquamosal holds the place of the temporal fascia in Mammals, and should be viewed as a sclerodermal ossification closing, in *Ichthyosaurus* as in *Labyrinthodon*, the vacuity between the upper and lower zygomatic arches, such as exists in *Crocodilia*. In *Ichthyosaurus* the prosquamosal (27′) is a broad, thin, flat, irregularly-shaped bony plate, smooth and subconvex outwardly, wedged into an interspace between the postfrontal, postorbital, zygomatic, tympanic, and mastoid bones.

The chief vacuities in the skull are:—In the occipital region (Tab. XXII, fig. 1), the 'foramen magnum' or neural canal of the occipital vertebra (^{n}), the 'occipito-parietal,' (*o p*), and the 'auditory' (^{m}); on the upper surface (Tab. XIX, fig. 1), the 'foramen parietale' (*f*) and the 'temporal fossæ' (T); on the sides (Tab. XX), the 'orbits' (*o*) and the 'nostrils' (*n*); on the lower surface (Tab. XXI) the 'palato-nares' (*p n*), the 'interpterygoid' (*s*), and the 'pterygomalar' (*y*)[3] apertures.

The 'foramen magnum' is formed by the basi-, ex-, and super-occipitals, the last having a nearly equal share with the exoccipitals; the basioccipital contributes the least

[1] Described as "apparently a distinct and peculiar bone" of the orbit in the 'Report' for 1839.

[2] This is termed "squamosal" in the Lectures above cited (1858), p. 392. The recognised distinctness of this bone in *Ichthyosaurus* inclined me in 1839 to view the zygomatic and squamous parts of the temporal bone of anthropotomy as essentially distinct elements; a view which subsequent extensions of comparison enforced me to abandon.

[3] 'Pterygomaxillary' in Crocodiles and Lizards, 'Anat. of Vertebrates,' vol. i, pp. 156 and 157, fig. 98, *y*.

part of any. The occipito-parietal vacuities are larger than in *Crocodilia*, smaller than in *Lacertilia;* they are bounded mesially by the ex- and superoccipitals, laterally by the parietals and mastoids, below by the paroccipitals.

The auditory aperture, or 'meatus' (Tab. XXII, fig. 1, *m*), is bounded by the tympanic and zygomatic. The tympanic takes a greater share in the formation of the 'meatus auditorius' in many Lizards; in Crocodiles it is restricted to that which it takes in Ichthyosaurs.

The orbit is remarkable for its large relative size and backward position: in the former character the Lizards, in the latter the Crocodiles, approach the Ichthyosaurs. The cavity is formed by the pre- and postfrontals above, by the lacrymal in front, by the postorbital behind, and by the long and slender malar below. In Crocodiles, and in most Lizards, the frontal or mid-frontal enters into the formation of the orbit, and in some Lizards (*Stellio*, *Agama*) the maxillary also. In Chameleons, both the frontal and the maxillary are excluded from the orbit.

The external nostrils are not homologous with the single medial one in the Crocodiles, but answer to the parial nostrils in Lizards, and to the supplementary apertures bounded by the nasal, lacrymal, and maxillary bones in the Teleosaurs. In Lizards the lacrymal is usually excluded by the maxillary from the nostril. In *Ichthyosaurus* the nostril (*n*) is a longish triangular aperture, with the narrow curved base behind; it is bounded by the lacrymal, nasal and premaxillary (22), sometimes also by the maxillary bones, and is usually distant from the orbit by less than its own long diameter. Like the orbit, the plane of its outlet is almost vertical.

The interpterygoid vacuity (Tab. XXI, fig. 1, *s*) is a very long and narrow triangular one; its base is behind, and is bounded by the anterior concavities of the basisphenoid. As it advances it is divided for a certain extent by the presphenoidal rostrum; the lateral boundaries are due exclusively to the pterygoids, which, converging, reduce the aperture to a point. In this formation, *Ichthyosaurus* resembles *Iguana*, but in *Varanus* the palatines enter into the formation of the palatal vacuity in question.

The pterygomalar vacuity (Tab. XXI, fig. 1, *y*) may be described as the lower outlet of the temporal fossa; it is bounded laterally by the zygomatic and malar, chiefly the latter bone; posteriorly by the tympanic, anteriorly by the maxillary, mesially by the ectopterygoid and pterygoid; the outer deep emargination of the latter bone relates to the passage of the large temporal muscles for insertion into the mandible. The larger proportion which the maxillary contributes to this vacuity in recent Saurians suggested the term 'pterygo-maxillary,' applied to it in the undercited work.[1]

The palato-nares (ib., *pn*) are relatively smaller than in most Lizards, and are circumscribed by the palatine, ectopterygoid, maxillary, and premaxillary bones. In Lizards the ectopterygoid is excluded from its formation, and the position of the palato-naris is more

[1] 'Anatomy of Vertebrates,' vol. i, p. 156.

advanced than in *Ichthyosaurus*. The *Crocodilia* depart widely from the *Ichthyosauri* in their single and backwardly placed palatal nostril.

The 'foramen parietale' (Tab. XIX, fig. 1, *f*) receives a much smaller proportion, if any, of the parietal bones than of the frontals in its formation (Tab. XXII, fig. 1).

The upper outlet of the temporal fossa (Tabs. XIX and XXIII, fig. 1, T) is bounded mesially by the parietal, laterally by the mastoid and postfrontal, behind by the mastoid and parietal, in front by the postfrontal; the lateral or outer wall of the fossa is formed by the mastoid, postfrontal, prosquamosal, postorbital, malar, and zygomatic bones.

More or less of the circle of sclerotic plates are commonly preserved in the fossil skulls of *Ichthyosauri*. They are of an irregular, oblong, quadrate form, joined together by squamous or overlapping sutures at their longest sides. The hind part is usually about half the length of the plate, and is very thin, ending in a trenchant border; the front or pupillary corneal border is thicker, shorter, and nearly straight. From this border each plate extends, raylike, outward, for more than half its length, then suddenly bends towards the back of the eyeball, defining and encasing its periphery, and indicating the extreme oblateness of that visual spheroid. In the *Ichthyosaurus communis* I have counted seventeen of these sclerotic plates.

c. Pectoral and Pelvic Arches and Appendages.—The limbs of *Ichthyopterygia*, as the name of the order implies, resemble the fins of Fishes in the number of digital joints or segments, and, in some species, the seeming excess of digits beyond the typical 'five.' With the parial ones of Fishes these Reptilian fins also correspond, the anterior pair with the 'pectorals,' the posterior pair with the 'ventrals.'

The inverted arch[1] supporting the 'pectorals' is detached from the occiput, as in the Plagiostomes; that supporting the 'ventrals' is also detached from the 'sacrum,' but retains the position beneath the vertebræ, which, when coalesced, receive that anthropotomical name. The hinder arch[1] has gained a structure determinative of the homology with the hæmovertebral elements called 'pelvis,' and the limbs so supported are called 'pelvic.'

The pectoral arch (Tab. XXIV, fig. 4) consists of a pair of scapulæ (51), a pair of coracoids (52), a pair of clavicles (58), and an episternum (46). In some specimens there appears a trace of a pair of precoracoids.

The correspondence with the same arch in *Ornithoryhnchus* was pointed out and figured by CLIFT.[2] I have not seen an *Ichthyosaurus* in which the clavicles were confluent mesially as a single bony arch, resembling the Avian 'furculum;' but such confluence does take place in the full-grown or aged Monotremes. No sternebers succeed the episternum in *Ichthyosaurus* as they do in *Ornithorhynchus*.

The episternum is small; each clavicle exceeds the length of the anterior transverse

[1] The definition of 'girdle' in our Dictionaries is inapplicable to these parts of the skeleton.

[2] 'Philos. Trans.,' MDCCCXVIII, p. 32, pl. ii.

ray; the medial longitudinal ray or stem does not exceed the transverse portion in extent. The clavicles are powerful bones, pointed at each end, overlying the transverse rays of the episternum, and continued along the anterior border of the scapulæ towards or near to the 'base' or free extremity of those bones; the joints are rough or sutural. The scapulæ are oblong, subcompressed, truncate at the free or basal end, thickened and broadened at the opposite or articular end for the two joint-surfaces of the coracoid and humerus (53) respectively.

The two pairs of limbs (ib., fig. 1, *s*, *p*) have been found in every sufficiently preserved skeleton, and where such fins have been lost their supporting arches or some elements thereof have usually indicated their existence. Of these limbs the anterior or pectoral (*s*) surpass in size, but in different degrees according to the species, the posterior or pelvic (*p*) pair. They appear to be most nearly equal in size in the skeleton, in part restored, of the *Ichthyosaurus platyodon* (Tab. XXVII, fig. 1), but confirmatory evidence of the degree of difference is desirable in regard to this species. The pelvic pair is the smallest relatively in *Ichthyosaurus latimanus*, *Ich. communis*, and *Ich. breviceps*, but the inferiority is nearly the same in *Ich. intermedius* (Tab. XXVI, fig. 1).

In all the species the digits are supported by flattened, subquadrate, hexangular, pentangular, transversely quadrate, or rounded phalanges, exceeding in number in each digit that known in any other Reptile, and recalling the many-jointed rays of the pectorals and ventrals of Fishes.

The shorter-snouted species have the greater number of digits, with more and smaller phalanges; as the jaws proportionately elongate the number of digits decrease, and their phalanges become relatively larger and fewer.

In all Ichthyosaurs the pectoral limb includes a humerus (see the typical restoration, Tab. XXIX, fig. 1, 53), two antibrachials (54, 55), three proximal carpals (56), and four distal ones (56′), from which the more numerous series of ossicles (57) are continued. I shall here limit the description of this part of the skeleton to the modification presented in the *Ichthyosaurus communis* (Tab. XXIV, fig. 1, *s*).

In this species the length of the humerus is but one fourth more than its breadth, and this is greater at the proximal than the distal end. The joint-surface of the head of the bone is subconvex, produced outwardly or anconally upon a thick deltoid ridge, subsiding half way down the shaft; there the ancono-thenal compression becomes more marked and is continued to the distal end, which is pretty equally divided into two subconcave, almost flattened, surfaces for ligamentous union with the antibrachials.

Assuming the prone position of the fin, which presents to outside view its anconal surface, as in Fishes, the anterior antibrachial represents the radius (54), the posterior one the ulna (55). Both bones are pentagonal by reason of the truncation of their distal approximated angles, which give lodgment to the proximal angle of the middle hexagonal carpal bone; the radial and ulnar carpals (56) are transversely oblong, and the quadrangular shape is but slightly disturbed by the production of their contiguous borders into the

intervals between the midcarpal and the two distal carpals, which it partly supports. The radial and ulnar ossicles (56′, 56′) of this third series from the humerus are extended transversely; the four of the following series articulate each with its corresponding carpal.

The series of three bones (Tab. XXIX, fig. 1, 56) presents the same relation to the antibrachials as does the proximal row of carpals in *Testudo*;[1] and the series of four ossicles which follows may be homologised with the distal series of carpals in the same number in *Testudo*. In this case the next transverse row of four ossicles, the third from the antibrachium, may be regarded as metacarpals (57). According to this view the radial metacarpal (57′), not the ulnar one (57) supports two digits, and the normal digits in *Ichthyosaurus communis* are thus five in number (I, II, III, IV, V). Each consists of a series of flattened, somewhat transversely extended ossicles, of which I have counted thirty and upwards in the two ulnar digits of the present species; they are rather fewer in the two radial and the mid-digits. But, in addition to these multiplied digital joints there are two superadded marginal series of ossicles; that (I′) on the radial border of the fin begins between the second and third joints of the radial digit, and is continued to near its extremity. The series (V′) along the opposite, ulnar, margin, begins at the interval between the ulnar proximal and distal carpals, and is also continued to near the extremity of the fifth normal digit. These supplementary ossicles are more rounded in shape than the normal phalanges, but, like these, progressively decrease in size to the tapering end of the fin. At first view, apart from the preceding homological analysis of the bones of the fore limb of *Ichthyosaurus*, they seem to show that seven digital series are present in that fin of *Ich. communis*.

All are enveloped in one sheath of smooth integument, which is continued beyond the framework to an obtusely pointed end, and likewise extends some way beyond the hinder or ulnar border of the bones, where it seems to have been supported by numerous fine cartilaginous rays unless the appearance be interpreted as due to parallel bifurcate wrinkles of the skin (Tab. XXIV, fig, 5).[2]

The ilium (Tab. XXVI, fig. 5, 62) is an oblong, subcompressed bone, slightly enlarging at the acetabular end to form the articular surfaces for pubis, ischium, and femur; sometimes, also, more slightly expanding to the opposite free flattened end. This part, if attached to any of the vertebræ, would be so by ligamentous or soluble tissue. The length of the ilium does not exceed, usually, that of three contiguous centrums.

The ischium (ib. 63), of minor length, is thickened at the acetabular end, which shows facets for the ilium, the pubis, and its share in the shallow cotyloid cavity for ligamentous attachment of the head of the femur. The body of the ischium expands, more or less in different species, to its free non-articular border, anterior to which it unites synchondrosally with the pubis. This (ib., 64) is usually a somewhat longer bone; it also expands

[1] 'Anat. of Vertebrates,' vol. i, p. 174, fig. 108, *a*, *d*, *c*.

[2] 'Transactions of the Geological Society,' 2nd series, vol. vi, p. 199, pl. xx.

to join the ischium at its lower end; the opposed borders of the two bones are concave, and inclose a long and large 'obturator' vacuity.

Modifications of these pelvic elements are shown in *Ichthyosaurus communis* and *Ich. latifrons*, and will be noticed in some other species.

The femur (Tab. XXVII, fig. 1, 65) resembles the humerus, but is smaller and usually rather less broad. Its distal end supports two cnemial bones, repeating the shape and relative proportions of the antibrachial ones. To these succeed three tarsal ossicles, which support four series of digital ossicles. But in *Ich. communis* the anterior or tibial series soon bifurcates, and supplementary ossicles are applied to those of the fibular or hinder digit. The shape of the ventral or pelvic fin thus supported is similar to, but relatively less broad (in *Ich. communis*) than, the pectoral one.

The rare illustration given in Tab. XXIV, fig. 5, is of a pelvic fin.

d. Osteological Summary.—At the risk of some repetition the following remarks, the result of such comparisons as I have had time or means of extending over the cold-blooded air-breathers, may not be unacceptable. The comparison with existing *Reptilia* is almost restricted to the Lacertian and Crocodilian modifications.

In Crocodiles the exoccipitals leave an intervening tract of the basioccipital, which thus takes its share in support of the 'medulla oblongata'; in Lizards the exoccipitals meet upon the basilar element, as in *Ichthyosaurus*, but the extinct Reptile differs from both in the exclusive formation, by the basioccipital, of the condyle articulating with the atlas. Such joint in Fishes is afforded by the basioccipital only, but the articular surface, as a rule, is concave instead of convex. The superoccipital is excluded from the foramen magnum in Crocodiles, but contributes, in Lizards, a share thereto, as in *Ichthyosaurus*. The paroccipital is confluent with the exoccipital in both Crocodiles and Lizards, as it is in Plesiosaurs.[1] It remains distinct in Chelonians as in Ichthyosaurs.

The extension of the mastoid upon the occipital region of the skull gives it an aspect of solidity more like that in Crocodiles than in Lizards; but this is an adaptive conformation, and depends on the need of an extent of bony surface for the implantation of the powerful nuchal muscles mainly concerned in wielding a head produced into long and heavy jaws, beset, as a rule, with formidable teeth; it also relates to the stability of the prow of the Fish-lizard in cleaving the watery element. The occipital aspect of the diverging extensions of the parietals, and the presence of the 'fontanelle,' called 'foramen parietale' in Plesiosaurs[2] as well as Ichthyosaurs, are more decisive instances of the closer affinity of Lizards, than of Crocodiles, to the antecedent marine types of *Reptilia*. No part of the parietal extends upon the occiput in Crocodiles, but this extension holds in Plesiosaurs as in Ichthyosaurs.

In adaptive relation to the mandible and its armature I regard the relative size and

[1] *Ante*, p. 8.

[2] Ib., Tab. IV, fig. 1, 7.

shape of the tympanic, the number of bones amongst which it is wedged, and the double buttresses extended on each side from the facial to the cranial part of the skull. In these characters the Ichthyosaurs resemble the Crocodiles; but the upper or post-fronto-mastoid zygoma and the lower malo-zygomatic one are present in some extinct as well as existing Lizards, *e.g.* *Rhynchosaurus*[1] and the *Rhynchocephalia*.[2]

In the exclusion of the mid-frontal from the orbit *Ichthyosaurus* differs from the Crocodiles and from most Lizards, but it is in the Lacertian order only that exceptions occur of repetitions of this Ichthyosaurian structure.[3] In the position, construction, and parial character of the external nostrils the Lizards repeat the Ichthyosaurian and Pleiso-saurian type, from which the Crocodiles have departed, but the lacrymal is excluded from the formation of the nostril in all Lizards. In the small relative size of the maxillaries, especially as compared with the premaxillaries, *Ichthyosaurus* differs from both Plesiosaurs and Crocodiles, and still more from Lizards: here we have in Fishes the nearest resemblance to the subjects of the present Chapter. Nevertheless, as in *Lecertilia*, the anterior boundary of the external nostril is formed by the pre-maxillary; and, as the marine *Reptilia*, like the marine *Mammalia*, needed to have the nostrils at or near to the upper part of the head, so, agreeably with the Lacertian type, the premaxillaries, however they might be produced forward, retain in *Ichthyosaurus*, as in *Plesiosaurns*, the posterior relations with their antorbital nostrils.

Both Lacertians and Crocodilians differ from Ichthyosaurs in the connections of the nasal with the maxillary. The Crocodiles resemble them in the inter-pre-maxillary suture; its presence is an exception in Lacertians, the Rhynchosaurians and Rhynchocephalians[4] again affording such examples; I have found it obliterated in a *Plesiosaurus dolichodeirus*.[5] In the position and formation of the palatal nostrils the Lacertians agree with, whilst the Crocodiles widely depart from, the Ichthyosaurian type. The apertures are distinct or parial in the Plesiosaurs, but are placed far back.[6]

In the structure of the mandible the dentary resembles that element in Lizards, and differs from that in Crocodiles, in being pierced externally by a longitudinal series of nervovascular foramina; it differs, also, from the dentary in Crocodiles in its posterior termination being above instead of beneath the fore end of the surangular. In the amphicœlian Crocodiles the vacuity between the angular and surangular is much reduced in size; it is still smaller in Rhynchocephalians; it is absent in Ichthyosaurs, as in Plesiosaurs[7] and most Lizards.

In the conformation of the posterior angle and the robustness of the articular

[1] 'Trans. Cambridge Philos. Society,' vol. vii, 4to (1842), p. 350, pl. v.

[2] 'Catal. of Osteological Series in Mus. Coll. Surgeons,' 4to, 1853, p. 143, No. 663; and GÜNTHER. 'Phil. Trans.,' MDCCCLXVII, p. 32.

[3] In *Chameleo parsoni*, *e.g.* CUVIER, 'Oss. Foss.,' v, pt. ii, pl. xv, fig. 80.

[4] Pl. xvi, fig. 1, 22. "On the Affinities of Rhynchosaurus," 'Annals and Mag. of Nat. History,' iv, 1859, p. 237.

[5] Pl. iii, fig. 1.

[6] Pl. xvi, fig. 2, *r*, *r*.

[7] Pl. ii.

extremity of the mandible the jaw of *Ichthyosaurus* more nearly resembles that of the Crocodiles than of the feebler Lizards, but in the mandibular structures indicative of affinity these latter existing Reptiles manifest their closer connection with the *Ichthyosaurus*. This is conspicuously seen in the absence of distinct alveoli and the lodgment of the teeth of both upper and lower jaws in a continuous open channel, the inner wall of which, in the mandible, is in a large proportion contributed by the splenial element. But the cement-clad base or root of the tooth seems not to become anchylosed to the alveolar tract or groove in *Ichthyosaurus*, but to remain free, till shed, as in Crocodiles. Although a portion of the pulp-cavity may persist in the fully developed tooth after the base or root becomes consolidated by a mass of interblended osteodentine and cement, into this mass the crown of the successional tooth presses, and occasions a cavity by absorption.[1] In no case have I found evidence of this successive supply of new teeth in the Triassic or Permian Theriodonts: herein differs their dentition from both Crocodilian, Dinosaurian, Lacertian, and Enaliosaurian *Reptilia*.

In most Lizards the hyoid bones present modifications which relate to the size and uses of the thick, or long, and commonly bifurcate, tongue. In *Ichthyosaurus* the apparatus is reduced to the same number of pieces as in the Crocodile, in which it is less subservient to the support and movements of the tongue than to the mechanism for defending the larynx and pharynx from the entry of water during the struggles of a submerged prey, when the mouth of the air-breathing destroyer is necessarily exposed to the free ingress of the aquatic medium. The condition of the hyoid apparatus in the *Ichthyosaurus* indicates that its tongue may have been but little better developed than in the Crocodile, and, since the Ichthyosaur obtained its food under the same circumstances which necessitate the hyoid and lingual modifications in the Crocodile, it may be inferred that the hyoid arch was physiologically related to the working of a similar valvular apparatus for defending the orifice of the air-tube from the water admitted into the mouth during the capture of the fishes, the remains of which have been found in the region of the alimentary canal of the great Sea-lizards.

The modifications of cranial structure of the known kinds of *Ichthyosaurus* are chiefly presented by the upper and lower jaws, which become elongated and attenuated in degrees exemplified by the species next to be described. With these modifications are associated increase of number with decrease of size of the teeth, and their total disappearance, finally, as in the Ichthyosauroids of the upper Jurassic beds of Wyoming and some other American localities. For these edentulous Ichthysaurs, their discoverer, Prof. Marsh, has proposed the generic name *Sauranodon*;[2] it is probable that, as in the

[1] 'Catalogue of the Fossil Reptilia and Pisces in the Museum of the College of Surgeons,' 4to, 1854, p. 40, Nos. 139, 140. In No. 141 I point out that in some of the teeth "the pulp-cavity has been obliterated in the crown as well as in the base of the tooth." See 'Quarterly Journal of the Geological Society' for May, 1879, pp. 189 and 199.

[2] 'American Journal of Science,' vol. xvii, p. 85, January, 1879; ib., vol. xix, p. 169, February, 1880.

case of *Cetacea*, showing minor modifications than do the toothed *Ichthyopterygia*, other generic terms for some of these species may be proposed.

C. Species.

a. Ichthyosaurus breviceps, *Ow.*, Tab. XXV.

In the skeleton of this species (Tab. XXV, fig. 2) the skull is almost equally divided between the antorbital part and that behind; it is about one sixth the length of the entire body, as represented by the vertebral column. This includes, in the specimen figured, 125 vertebræ, of which 46 lie between the skull and pelvis. The neural spines of such trunk-region are lofty, equalling along its major part the vertical diameter of the rest of the vertebræ taken from the base of the spine. The intervals between the spines are very narrow. The centrums are largest at and near the pelvic region. The fore fin has five normal digital series, with smaller supplementary ossicles along both fore and hind borders; it is twice as long and as broad as the hind one.

The specific characters are more fully exemplified in specimens of the skull of larger individuals, which show that the proportions of the rostrum to the rest of the skull in the smaller skeleton may be due to nonage, but the cranial conformation is the same.

The skull with the right side shown in profile (Tab. XXV, fig. 1) was discovered in the thick Liassic Limestone, called "Broad Ledge," at Lyme Regis; and, as usual with such fossils from this locality, is somewhat compressed.

The length of the mandible is 3 feet 7½ inches; that of the upper jaw from the fore part of the orbit is barely 2 feet; and from the fore part of the nostril is 1 foot 4½ inches. These proportions indicate the character of the skull which suggested the specific name.

The species which *Ichthyosaurus breviceps* is thus shown to have approached in size is *Ich. platyodon*, Conybeare; but, like *Ich. trigonodon*, Theod.,[1] it had fewer and proportionately larger teeth.

In the portion of the upper jaw in advance of the nostril of a well-preserved skull of *Ich. platyodon*, the number of teeth is thirty; whilst in *Ich. breviceps* they do not exceed eighteen. In a corresponding extent of the lower jaw of *Ich. platyodon* the number of teeth is thirty-two; in that of *Ich. breviceps* it is twenty-two. The length of the skull from the back of the orbit to the fore end of the upper jaw, in *Ich. breviceps*, is three times and two thirds that of the long diameter of the orbit; in *Ich. platyodon* the length of the skull from the back of the orbit forwards is four times and one third that of the orbit in one specimen, and four times and a half that of the orbit in a larger specimen; the size of the eye and of its bony cavity not augmenting, apparently, *pari passu*, with that of the general bulk of the animal.

[1] And. Wagner, 'Beiträge zur Arten von Ichthyosaurus,' 4to, 1851, p. 34, tab. xvi, figs. 3—6.

The sclerotic plates, thirteen in number, have been compressed from within at the side opposite to that exposed, and the parts which were abruptly bent upon the midpart of the eyeball have been pushed into line, and fractured at the bend with the fore parts of those plates.

The mandible shows a specific variety in the proportions of its constituent elements. The angular (Tab. XXV, fig. 1, 31), which in *Ich. platyodon* has less depth, and in *Ich. communis* much less depth than the surangular, opposite the back part of the orbit, has in *Ich. breviceps* greater depth there, and it extends further forward, viz. within nearly one fourth of the fore end of the ramus, instead of terminating within one third (*Ich. platyodon*), or before it reaches half way to that end (*Ich. communis*).

The maxillary is excluded from the external nostril by the junction of the pre-maxillary (22) with the lacrymal (73). The malar (26) extends further forward in a slender pointed form, in advance of the orbit, between the lacrymal and maxillary (21). The hinder expanded sutural border of the nasal (15) is sculptured by some strongly marked ridges and grooves.

The swollen base of the tooth is impressed by longitudinal grooves, fewer in the upper (ib., fig. 3) than in the lower ones (fig. 4); the enamelled crown shows finer longitudinal lineations, and the fore border is slightly trenchant. The crown is relatively longer and more slender than in *Ich. trigonodon*, and less compressed than in *Ich. platyodon*. The teeth come nearer in character to those of *Ich. communis*, but are relatively larger, and fewer in a given extent of the jaws, than in that species.

In all the characters above defined as differentiating the present species from those with which it is compared, and to which it makes the nearest approach in the Ichthyosaurian series, the skull figured as that of *Chiroligostinus* in plate 3 of HAWKINS's 'Great Sea Dragons,' fol., 1842, agrees with *Ich. breviceps,* and the name might be adopted were it not applied by that author as a synonym of *Ich. platyodon*. Besides the Dorsetshire locality above named, *Ichthyosaurus breviceps* has been discovered in the Lower Lias in the neighbourhood of Brownish, Glastonbury, Somersetshire, in the Zone of *Arietites Bucklandi*.

b. ICHTHYOSAURUS COMMUNIS, *Conybeare*. Tab. XX, figs. 2, 5, 5′; Tab. XXIV, fig. 1; Tab. XXVI, figs. 3, 4, 5.

The name was suggested by the evidences of this species being the most numerous that, at first, came to hand; but subsequent acquisitions seem to show another species to have a better claim on that ground, at least in the locality of the Lias formations in the South-west of England.

In *Ichthyosaurus communis* the length of the skeleton is about five and a half times

that of the skull, and the length of the 'snout,' or upper jaw, anterior to the orbit, is three and a quarter times that of the orbit

Of great breadth posteriorly, the skull narrows to the fore part of the orbits; thence the upper jaw contracts rapidly, afterwards gradually, to the anterior almost pointed end. As it advances the upper jaw becomes subcompressed. In profile, after the concavity due to the sinking of the cranium anterior to the orbit, the line goes straight to near the end of the upper jaw, where it rapidly sinks to the alveolar border.

The chief characters of the present species are afforded by the teeth and the pectoral paddles.

The teeth (Tab. XX, figs. 5, 5′) are more numerous and smaller than in *Ich. breviceps,* but, in comparison with the majority of the known species, are proportionately large. They have an expanded or ventricose root, contracting to a conical, slightly aduncate crown, with a subcircular transverse section. The apex is subacute, but there is no coronal trenchant margin; the enamel is impressed by fine longitudinal grooves, with intervening ridges. These finer ridges are somewhat abruptly divided from the coarser ones of the root by a smooth tract marking the base of the enamelled crown. Viewed in the series the teeth seem to taper less regularly, often more quickly, to the apex than in other species. The upper jaw bears on each side from forty to fifty teeth, of which sixteen or eighteen may be implanted in the maxillary bone, the rest in the premaxillary. Each ramus of the mandible may support a few teeth more than those opposed to them in the upper jaw.

The midfrontals take the chief share in the formation of the parietal foramen, and are excluded from the upper border of the orbit by the pre- and postfrontals. The sclerotic plates are sixteen or seventeen in number.

The nostril is bounded by a straight line above, contributed by the nasal bone, and by a curved line below, due to the lacrymal and premaxillary. The maxillary is excluded from that opening; it receives the pointed fore end of the malar in a notch; that slender bone forms the whole of the inferior border of the orbit.

In the mandible the surangular extends forward beyond the angular. The dentary elements unite to form the major part of the symphysis, a small hind portion being contributed by the splenials (Tab. XXVI, fig. 4, 32′). The symphysis so constituted had, in a lower jaw 2 feet 9 inches in length, an extent of 9 inches.

The vertebræ are shorter, or their centrums have a minor antero-posterior extent in proportion to their breadth, than in some other species (*Ich. intermedius, Ich. latimanus, e.g.*), but are longer than in *Ich. brachyspondylus.* I have counted forty vertebræ between the occiput and the "sacrum," conventionally so calling the centrum nearest the iliac bones. From this to the end of the tail follow, at least, one hundred vertebræ, of which seventy-five no longer support pleurapophyses. The total number of vertebræ in *Ichthyosaurus communis* may be set down at 140.

The episternum shows no marked specific character. The coracoids have the anterior

notch deeper than the posterior one (Tab. XXVI, fig. 3). The clavicles are long and strong, applied, as usual, to the fore border of the transverse rays of the episternum and to that of the scapulæ.

The bones of both fore and hind paddles have afforded the description given in the preliminary general account of the Ichthyosaurian skeleton (p. 62).

In the specimen (Tab. XXVI, fig. 3), in which the pelvic arch and limb are unusually well preserved, the ilium (ib. figs. 5, 62) is sabre-shaped or moderately curved backwards; in length $2\frac{1}{2}$ inches, with a breadth of 5 lines at the middle. The pubis (64) of the same pelvis is 2 inches 9 lines in length, 1 inch in distal breadth; both fore and hind borders are concave. The ischium (63) is nearly of the same length as the pubis, with a distal breadth of 9 lines, and a deeper concavity of the anterior border. The entire vertical extent of the pelvis is 5 inches.

The length of the pelvic paddle in the subject of fig. 1, Tab. XXIV, is $4\frac{1}{2}$ inches; that of the femur being 1 inch 7 lines. The extreme breadth of the paddle is 1 inch 10 lines. At this part there are five phalanges in transverse line, that number occurring at the fifth bone from the femur. The midtarsal encroaches further between the tibia and fibula than usual.

The *Ichthyosaurus communis* occurs chiefly in the Lias of Lyme Regis and Charmouth, Dorsetshire; in that of Street, Somersetshire, it is rarer than the *Ichthyosaurus intermedius*. Remains of *Ichthyosaurus communis* have been met with in the Lias near Bristol. This species is associated with *Ich. intermedius* and *Ich. tenuirostris* in the Lias of Barrow-on-Soar; it occurs, likewise, in the same formation at Stratford-on-Avon. In all these localities Ammonites of the species *Arietites Bucklandi* have been associated with the Ichthyosaurian fossils.

c. Ichthyosaurus intermedius, *Cb.* (Tab. XX, fig. 7, Tab. XXVI, figs. 1 and 2).

In this species the orbits are of moderate size,[1] and the facial portion of the skull in advance equals in length about three times the antero-posterior diameter of the orbital outlet. The teeth (Plate XXIV, fig. 7) are relatively smaller and longer than in *Ich. communis* (ib., figs. 5, 5′); the crown has a narrower base, is more acutely conical, with finer longitudinal striæ, and the root has less prominent ridges. The number of teeth is from thirty-five to forty on each side of both upper and lower jaws.

The entire length of the skeleton is from five to five and a half times that of the mandible.

In the best preserved specimens the number of vertebræ ranges between 130 and 140. In the space between the scapula and pelvic arches there are about forty vertebræ,

[1] Compare with fig. 3, Tab. XXIV, *Ichthyosaurus longirostris*.

which may be termed 'abdominal.' The neural spines increase in length and fore-and-aft diameter to beyond the middle of this region, and, by reason of their antero-posterior breadth, they are in contact with each other. The fin-bend of the tail occurs at about the seventy-sixth or eightieth vertebra.

The di- and par-apophyses become confluent at or about the forty-sixth vertebra, and such single 'transverse process,' or tubercle, disappears near the tail-bend.

The ribs are slender, and become flattened and longitudinally grooved along their distal halves. After the fortieth pair, or thereabouts, they become straight, short, rounded, without the groove, and resemble mere 'transverse processes.'

Three neural arches in the subject of fig. 1, Tab. XXVI, have been dislocated near the bend of the tail. In these, the neurapophyses are short and confluent, with a transversely broad, quadrate neural spine (Cut, fig. 5), the quadrature being due to an abrupt truncation of the spine.

Fig. 5.
Neural arch, front view.
Nat. size.

Fig. 6.
Caudal vertebra, side view.
Nat. size.

In the pinnigerous part of the column the neural arches (Cut, fig. 6) gradually lose breadth, gain length, and still more gradually lose height, the spine always predominating in the fore-and-aft diameter; the summit equals the centrum in that extent, and the neural spines of contiguous vertebræ touch, but do not overlap.

The vertical contour of the midpart of the centrum, above and below a more prominent convex part, is slightly concave. The borders show the moderate convexity or thickening, relating to the compressed characters of the pinnigerous caudals.

The neurapophyses in the basicaudal region seem not to have coalesced above, and the broad, laterally-impressed, and backwardly-produced part, simulates the half of a truncated neural spine. The short, straight, and inferiorly-situated pleurapophyses continue to be developed to near the tail-bend. The shorter hæmapophyses (Cut, fig. 6) are continued from the pinnigerous caudals to within a third part of the pointed tail-bend.

In the skull of *Ichthyosarus intermedius* the following characters may be noted.

The under surface of the basioccipital is but slightly excavated anterior to the condyle, and the 'foramen parietale' is almost wholly in a raised part of the hind end of the inter-

frontal suture. The maxillary is separated from the external nostril by a junction of the premaxillary with the lacrymal.

The sclerotic plates are often from fifteen to seventeen in number.

The surangular is deeper, and forms a larger proportion of the outer surface of the hind half of the mandibular ramus than the angular. It terminates or disappears at the usual point between the dentary and splenial, in advance of the angular; it develops on its upper border a small but well-marked coronoid angle bounding anteriorly the concavity under the hind part of the orbit. Beneath this angle or process begins the neurovascular groove, which extends, gradually shallowing, a short way forward. The splenial element begins to show at the lower margin of the ramus about the mid-length of the angular; it unites with its fellow to form the hinder two thirds of the symphysis mandibulæ (Tab. XXVI, fig. 2, 32′). The articular piece is brought into view by its partial dislocation backward in the right ramus of the subject of fig. 1, Tab. XXVI.

The stem of the episternum equals in length one half of the cross-bar; in receding therefrom it slightly expands and becomes flattened. In one young specimen a median cleft extended a short way forward from the end.

The clavicles are distinct, long, and less strong than in *Ich. communis*, feebly bent, with the concavity behind and within, gradually narrowing to each end, and having a sutural surface beneath and behind, some way along each end; the shorter one engrains with the episternal cross-bar, the longer one with the fore part of the scapula. Of this bone the fore border is straight, the hind one concave through the backward production of the humeral joint; near this the outer surface is slightly excavated. In the coracoid the humero-scapular articulation is of less relative extent than in *Ichthyosaurus communis*. The anterior notch is broader, but is as deep as the hinder one; the intervening tract, or neck, is relatively larger than in *Ich. platyodon* or *Ich. tenuirostris*.

The present species has afforded some ground of the restoration outlined in fig. 1, Tab. XXIX. The humerus is marked 53; the radius 54; the ulna 55. The fore border of the radius is entire, not notched. The antibrachium supports, as usual, three ossicles (56), followed by four rather smaller (56′). Regarding these as carpals, they support four metacarpal ossicles (57—57′), from which are continued five longitudinal series of progressively diminishing phalanges. The anterior or radial metacarpal (57′) supports two digits, of which the radial may be symbolised as I, the next series as digit II. The three other series, III, IV, V, are supported by their respective metacarpals. Each digit consists of numerous phalanges, progressively decreasing to the end. A series of small supplementary ossicles is applied to the radial border of digit I, and to the ulnar border of the digit V, so that seven ossicles may be counted in the same transverse line along the middle third or fourth of the series. The number of phalanges is, however, less than in *Ich. communis*, and the fin is relatively narrower. The characters of the fore paddle above defined are well shown in specimens from the Lias of Lyme Regis and of Street, in the British Museum.

In the pelvic fin the femur is longer in proportion to its breadth, and the distal expansion is relatively greater than in the humerus. The tibial ossicle of the three tarsals has an emarginate tibial border; the corresponding ossicle or phalanx of the second and third series shows the same character.

d. Ichthyosaurus platyodon, *Cb.* Tab. XX, figs. 4, 4′; Tab. XXVII, figs. 1, 2, 3.

The skull of *Ichthyosaurus platyodon* (Tab. XXVII, fig. 2), is somewhat longer in proportion to the trunk than in *Ich. communis.* Taking as the trunk the extent of the vertebral column to the pelvic arch, such extent includes, in the subject of fig. 1, one length and a half of the skull, while in *Ich. communis* (Tab. XXIV, fig. 1) it includes rather less than two lengths, and, in *Ich. intermedius* (Tab. XXVI, fig. 1) rather more.

The skull of *Ich. platyodon* is longer in proportion to its breadth than in *Ich. intermedius.* The jaws are stronger from the greater relative depth of the mandible and the less gradual attenuation to the rostral extremity. The orbit is of a full elliptic shape, with less approach to the circular, than in *Ich. breviceps* (Tab. XXV, fig. 1). It is relatively less than in the long- and slender-snouted kinds. The length of the rostrum anterior to the orbit is three and a half times the longitudinal diameter of that cavity.

The osseous circumpupillary ring includes thirteen sclerotic plates in the subject of Tab. XXVII, fig. 2. The surangular (ib., fig. 2, 30) disappears between the dentary (33) and angular (31). This element similarly disappears in a pointed form between the dentary (33) and splenial (32), beyond the midlength of the ramus.

A dental characteristic of the present species is that which suggested to Conybeare the name *platyodon;* the smooth enamelled crown (Tab. XX, figs. 4, 4′) being subcompressed, sharp-edged, and pointed; the longitudinal grooves of the tumid cement-clad root are soon lost upon the coronal base. I have counted 45—45 of these teeth in an upper jaw, and 40—40 in a lower jaw, and have noted that the crowns are more often snapped off than in the smaller species, which may be indicative of the greater violence with which they have been used.

From the occiput to the iliac bones there are forty-five vertebræ; thence to near the end of the tail may be counted seventy-five vertebræ; the total number in the skeleton probably somewhat exceeded 120. One of these vertebræ, from the hinder half of the abdomen, is figured (in the inverted position with the neural surface downwards) in Home's Memoir of 1816.[1] The neural spines are thicker, shorter, and more rounded superiorly than in *Ich. intermedius* or *Ich. communis.* The zygapophyses, especially the

[1] 'Phil. Trans.,' MDCCCXVI, pl. xiv.

anterior ones, are well developed, and the vertebræ of the trunk and basal moiety of the tail are strongly interlocked, though admitting some inflection. The ribs increase in length to the twenty-fifth pair; at the thirtieth pair they begin to shorten gradually, and, after the fortieth pair, more suddenly, becoming nearly straight at the forty-fourth pair. Thence they are continued like long transverse processes articulated by a simple head to the single di-parapophysis, as far as the hundredth vertebra.

The scapula (Tab. XXVII, fig. 3, 51) has a relatively broader humeral end than usual. It is preserved with the corresponding clavicle (ib., 58) in a portion of a huge skeleton of the present species in the British Museum.

The coracoid has a relatively larger or longer scapulo-humeral surface than in *Ich. intermedius*, and has a narrower and deeper anterior notch or emargination than in *Ich. communis;* the ento-sternal margin is rather thicker than usual. I have noted a specimen of this bone from Lyme Regis, of which the long diameter was 8 inches 4 lines, the short diameter 6 inches.[1]

The humerus is notable for its breadth, especially distally, compared with its length. The proximal rounded end, or 'head,' is tuberculate at its circumference, indicative of powerful ligamentous attachments to the scapulo-coracoid joint. The fore margin is more concave than usual. This latter character is still more marked in the radius, which, with the ulna, presents the generic shortness and flatness, with a slight excess of breadth, as compared with most other species. The anterior emargination is present also in the radio-carpal bone (Tab. XXVII, fig. 1, 54), and in the corresponding one in the following series. The next ossicle presents the common pentagonal form. Not more than three series of digital bones are preserved in the subject of figure 1, Tab. XXVII. A few supplemental ossicles are preserved at the radial border beyond the middle of the fin-framework. I have not found evidence of a greater number of pectoral digits in any remains of the present species. It seems to have been characterised by long and narrow, but powerful fore paddles.

In the pelvic bones the ilium (Tab. XXVII, fig. 1, 62) presents a straight, flattened, slender form. The ischium (ib., 63) is remarkable for its breadth, especially at its medial end. The pubis (ib., 64) is less expanded there; its anterior border is straight.

The femur (ib., 65) is longer in proportion to its breadth than the humerus; its proximal end shows a large depression, probably for the insertion of a stout ligament. The tibia (ib., 66) presents an anterior emargination, as in the radius (54); the same character is repeated in the two succeeding ossicles at the same margin of the fin-framework. Here, also, but three digital series are preserved, with a few small supplemental ossicles along the fibular border of the fin.

The disposition of the distal ossicles in both pairs indicates that the ligamentous or fibro-cartilaginous uniting medium of their framework may have been more abundant than usual, allowing greater flexibility of the terminal part of the long and narrow

[1] 'Report,' *ut supra*, 1839, p. 114.

paddles of *Ichthyosaurus platyodon.* The least incomplete skeleton of this huge species in the British Museum, the subject of Tab. XXVII, fig. 1, is from an individual of about 20 feet in length; but portions of others—the skull, for example, which may be seen at the Geological Society's Rooms at Burlington House—indicate a total length of the individual so represented, of at least 30 feet.

The Lias of the Valley of Lyme Regis is the chief depository of *Ich. platyodon,* but its remains are pretty widely distributed in the same Mesozoic zone. They have been found in the Lias of Glastonbury, of Bristol, of Scarborough, of Whitby, and of Bitton in Gloucestershire. The Ammonites associated with the bones of the subject of Tab. XXVII, fig. 1, are of the species *Arietites semicostatus*, characteristic of the greyish limestone (Lower Lias) of Lyme Regis.

e. Ichthyosaurus lonchiodon,[1] *Ow.* Tab. XX, figs. 6, 6′; Tab. XXVII, figs. 4—7.

This species, which appears to have attained a bulk second only to that of the *Ich. platyodon*, differs in the shape and smaller relative size of the teeth (Tab. XX, figs. 6, 6′). They are more slender in proportion to their length than in *Ich. communis* (ib., figs. 5, 5′), and are straighter than in *Ich. tenuirostris.* Their base is cylindrical, less ventricose than in *Ich. platyodon* (ib., fig. 4′), and more finely and regularly fluted than in *Ich. communis.* A smooth boundary divides the base from the enamelled crown, and this is traversed by fine longitudinal grooves converging to the apex. The transverse section of its base is nearly circular; it tapers gradually to the apex, which is nearer the posterior line or contour than the axis of the tooth.

The vertebral centrum has a greater proportional fore-and-aft extent than in *Ich. platyodon;* the neural arch and spine have a less vertical, in proportion to the fore-and-aft, extent (Tab. XXVII, fig. 6) than in *Ich. communis* or in *Ich. tenuirostris.* Forty-five of these vertebræ may be counted between the occiput and the pelvis; and as many beyond may be made out in the subject of fig. 4, Tab. XXVII, as brings the number up to 120, but the tail is incomplete.

The length of the rostrum anterior to the orbit (Tab. XXVII, fig. 5) includes little more than three longitudinal diameters of that cavity; it is thus relatively shorter than in *Ich. platyodon*, and it is relatively more slender than in *Ich. intermedius.* The mandible, however, does not partake of this proportion, but is nearly as deep and strong, relatively, as in *Ich. platyodon* (ib., fig. 2). The surangular (30) extends farther forward than the angular (31); both disappear in the usual pointed form. The nostril is divided from the maxillary by union of the premaxillary with the lacrymal. The pair of hyoid elements (cerato-hyals) are preserved *in sitû* in the subject of fig. 5; they are cylindrical,

[1] 'Report,' *ut supra*, p. 116.

almost straight, truncate at each end, which very slightly exceeds in thickness the rest of the bone. Each is about one fifth the length of the mandibular ramus.

The coracoid (Tab. XXVII, fig. 7) shows a deep anterior notch, with only a feeble concave outline at the corresponding part of the hind border of this bone. The clavicle is applied and suturally attached to the lower half of the fore border of the scapula. That border is nearly straight; the hinder one is concave through the backward production of the thickened lower end to contribute to the articular surface for the humerus. The anterior border of the radius and succeeding ossicle is emarginate. The chief phalanges of but three digits are preserved in the subject of Tab. XXVII, fig. 4. The character of the pectoral fin of the present species is probably rightly indicated in the main; and in such essentially tridactyle character *Ichthyosaurus lonchiodon* may agree with *Ich. platyodon.*

The lower or distal ends of ischium and pubis seem to be equally expanded; both bones are broader than the ilium. The ventral fin has been dislocated and bent backward close to the spine. The homotypal ossicles show the same emargination as in the pectoral fin.

The neural spines are relatively short (ib., fig. 6).

This species has hitherto been found only at Lyme Regis; it appears to be a rarer Liassic Ichthyosaur than the three preceding ones. The skeleton above described was discovered by Miss Mary Anning, to whom the discovery and extrication of many rare and interesting fossils of the Lias of this locality are due.

f. Ichthyosaurus longifrons, *Ow.* Tab. XIX, figs. 1—5; Tab. XX, fig. 1; Tab. XXI, fig. 1; Tab. XXII, fig. 1; Tab. XXIII, figs. 2—5.

The characters of this species are those in which the subjects of the above plates and of the general description of the cranial organisation of the genus differ in the specific modifications referred to in other sections of the present Chapter.

From the Upper Lias, with remains of *Ammonites bifrons,* of the Cotteswold Hills. The more complete cranial specimen from the same Liassic zone at Curcy, Normandy, has afforded the subjects of the figures in the plates above cited.

g. Ichthyosaurus latifrons, *Kön.* Tab. XIX, fig. 6; Tab. XXIII, fig. 1.

In the year 1825 Mr. König, Keeper of the Department of Mineralogy, British

Museum, published a series of lithographs of fossils, in a folio form, with brief notices of the subjects, reaching to number 100. Beyond this, names alone are given at the foot of each plate, and No. 250 of plate xix bears that of *Ichthyosaurus latifrons*. It is a very reduced view of a mutilated skull and portion of the vertebral column, with some vertebræ outlined of the natural size. The specimen is stated to have been obtained from Lyme Regis.

Of this specimen a view of the upper surface of the skull is here given of the natural size, in Tab. XXIII, fig. 1. The upper apertures of the temporal fossæ (T, T) are nearly equilaterally triangular in form, the base being external and slightly exceeding the sides, which converge to the cranium proper. The sagittal suture (7) persists, but the frontal one is obliterated, and the midfrontals (11) constitute a single symmetrical bone, which is moderately convex both lengthwise and crosswise.

The "foramen parietale," of a full ovate figure, is formed wholly by the frontal, the apex alone forming the beginning of the parietal suture.

The postfrontal (12) extends upon the coronal suture, and overlaps part of both parietal and frontal bones. The nasal (15) overlaps the fore part of the frontal, and divides that bone from the prefrontal (14). The sides of the skull converge rapidly to the beginning of the snout. A breadth of cranium across the temporal apertures of 7 inches is reduced to 2 inches anterior to the nostrils (ib, *n*).

Additional characters of the present species are afforded by a second specimen from Lyme Regis acquired by the British Museum. It is a skeleton, lacking both ends, but including the trunk, with chief part of the skull and basal portion of the tail, the total length being 4 feet 10 inches. From the occipital condyle to the pelvis it measures 2 feet 6 inches; the length of the preserved portion of the skull is 1 foot 4 inches. In this specimen is instructively shown the sudden slope by which the broad cranium descends into the rostrum. The orbit is correspondingly large, its vertical diameter is 5 inches, its antero-posterior one is $4\frac{1}{2}$ inches. The sclerosteal circle is composed of correspondingly large plates, of which seven are preserved.

The vertical diameter of the base of the rostrum, taken across the middle of the nostril, is but 1 inch 3 lines. The premaxillary is impressed by a longitudinal groove, running about three lines above the alveolar border.

The teeth are long, slender, slightly recurved; six or seven may be counted in an extent of two inches of the alveolar groove. The length of the crown of the best preserved is 6 lines, its basal breadth being 1 line.

In the composition of the mandible the angular element is unusually short; it disappears parallel with the hind border of the orbit. On the other hand, the surangular is longer than usual, but its chief character is the continuation of the forwardly-directed nervo-vascular foramen, usually present below the hind border of the orbit, into a groove continued forward, towards the lower border of the ramus, and terminating at a vertical line dropped about a nostril's extent in advance of that opening. A second

and narrower longitudinal groove extends along the dentary about two lines below the alveolar border.

The length of the jaws cannot be determined in this or in the typical specimen, their fore end being broken off, but sufficient remains to indicate that *Ich. laticeps* belonged to the long and slender-jawed species, with small and slender teeth to match; and associated, as in *Ich. tenuirostris,* with a powerful fore paddle, supported by comparatively few and relatively large phalanges.

The proportion of the longitudinal to the transverse diameter of the vertebral centrums is contrasted with those of the *Ich. brachyspondylus* in Tab. XXIX, fig. 6. The neural spines of the dorsal vertebræ are relatively short and with distinct intervals. Thirty-eight are preserved between the scapula and ilium.

The scapula is characterised by the greater relative expanse of its articular end in comparison with the breadth of the body, resembling in this respect that of *Ich. platyodon.* The coracoid has a deep anterior emargination, and a shallow posterior one; the antero-posterior breadth of this bone is 4 inches, the transverse extent is 3 inches. The left coracoid, with the corresponding humerus and a few paddle-bones, have been pushed dextrad and appear beneath the right coracoid, from which the corresponding paddle has been removed.

The pelvic bones of the right side are well shown. The ilium, 2 inches 4 lines in length, is directed obliquely backward and downward; its upper end is one inch in breadth. The pubis, 2 inches 3 lines in length, has a distal breadth of 11 lines; its fore border is almost straight. The ischium, 2 inches in length, has a distal breadth of 1 inch 3 lines. The margin towards the pubis is more concave than the opposed one of the latter bone. The hind border of the ischium is moderately concave.

Compared with the same bones in *Ichthyosaurus communis* the pelvic elements are more robust.

Of the structure of the appendage of the pectoral and pelvic arches, or fins, I have not, as yet, obtained satisfactory evidence.

The fossils which have served in the present section of the Chapter have been obtained from the Lias of Lyme Regis and Charmouth.

h. Ichthyosaurus acutirostris,[1] *Ow.* Tab. XXIV, fig. 2.

This species is so named from the slender, sharp-pointed form of the snout, unaccompanied by such proportions of length as characterise the *Ichthyosaurus tenuirostris* and *Ich. longirostris* (ib., fig. 3).

[1] 'Report,' *ut supra*, p. 116.

The length or fore-and-aft diameter of the orbit in the subject of the above plate is 6 inches, that of the part of the skull anterior thereto is 18 inches 7 lines. Both upper and lower jaws are impressed by a deep and narrow longitudinal groove near to and parallel with the alveolar border. The osseous sclerotic part of the eyeball occupies about two thirds of the long diameter of the orbit.

The teeth are intermediate in character and in number between those of *Ich. intermedius* and *Ich. tenuirostris.*

The few trunk-ribs preserved in my present subject are slender, rounded, ungrooved, and have a feebly-produced anterior margin along their proximal fourth.

The mesial border of the coracoid is sinuous, the articular surface for the episternum being better defined and more tumid than usual. The surface of the lateral or outer border for articulating with the scapula and humerus is strongly developed. The length of the coracoid in the specimen described is 7 inches, its breadth $7\frac{1}{2}$ inches.

The humerus is 7 inches in length and $5\frac{1}{2}$ inches in breadth at the distal end. Of the fore paddle three digital series and a small portion of a fourth are preserved, but in such juxtaposition as to leave little doubt as to any considerable part of the fin-bones being lost. These, along the fore or radial border, including the radius, radio-carpal, and succeeding ossicle, are emarginate; the rest have that border entire and moderately convex. After the fifth ossicle from the humerus the subquadrate merges into the transversely oval form. From the inclination of the radial digit toward the middle of the fin, a bifurcation is indicated at about the ninth ossicle from the humerus, and an irregular scattered series of small, full-elliptic, and circular bonelets, may be interpreted as an additional digit to the three normal ones, the more direct continuation of digit II now extending down the centre of the bony paddle. An irregular ulnar series like that on the radial side is partially shown. If there should be lack of osseous evidence of the breadth of the fore fin there is less of its length, which seems to have been two thirds that of the skull, and this is due rather to the size than the number of phalanges. The preserved basal portion of the left paddle repeats the character of the corresponding part of the right one above described, and so far confirms the inference as to the specific character of the fins associated with the acuminate one of the skull.

The fossils on which the above species of Ichthyosaurs is founded are from the Lias of Whitby, Yorkshire.

i. Ichthyosaurus tenuirostris, *Cb.* Tab. XX, fig. 8; Tab. XXI, fig. 3; Tab. XXVIII, figs. 1—6.

The characters which, in 1822,[1] strikingly distinguished the present from the then

[1] 'Trans. of the Geological Society,' 2nd series, vol. i.

determined species of *Ichthyosaurus*, were the great length and slenderness of the jaw-bones, suggesting the proportions of those of the Crocodilian gharrial; and which, in combination with the large orbits and low broad cranium, gave to the skull a resemblance to that of a gigantic woodcock (*Scolopax*), with a bill armed with teeth.

The length of the snout is chiefly due to the prolongation of the premaxillaries (Tab. XXVIII, fig. 2, 22) and dentaries (ib., 33). The length of the skull anterior to the orbit is somewhat less than four times the antero-posterior diameter of that cavity.

The parietals retain their sagittal suture, the fore part of which recedes in a greater proportion than usual to contribute to the foramen parietale. Their posterior bifurcation is applied, in the occipital region, to the super-occipital, which is broad and arched. The outer end of each parietal prong is obliquely truncate for the suture with the mastoid (ib., fig. 2). This, as usual, forms the blunt but prominent supero-lateral angles of the hind part of the cranium. The midfrontals (ib., 11) retain their suture, their lateral border articulates with the prefrontal (14) and the superorbital, or a forward extension of the postfrontal. This element articulates with the lateral border of the parietal and combines with that bone in forming the upper three fourths of the temporal fossa, the lower boundary of that cavity being completed by the mastoid.

The orbit is bounded behind chiefly by the postorbital. The malar is unusually long, extends from the lacrymal (73) to form the rest of the anterior boundary of the orbit; then, continuing to circumscribe it below, the malar curves with a rather abrupt bend upwards to join the postorbital, and by an oblique suture the zygomatic. This bone is continued obliquely backward to contribute to the external meatus auditorius and to articulate with the tympanic.

The sclerotic plates preserved in the orbit of the subject of fig. 2 bend more abruptly than usual towards the back part of the cavity, suggesting a depressed spheroid form of the eyeball.

The nasal (15) presents the usual connections; the margin which it contributes to the upper part of the nostril (*n*) is slightly convex, encroaching on that opening, which seems to be rather longer, proportionately, than usual: in the subject of fig. 2 it is $2\frac{1}{2}$ inches in length.

In the composition of the lower jaw, I have noted that the angular element extends a short way in advance of the surangular before disappearing externally. The point of the surangular enters a notch in the hind part of the dentary, about half an inch anterior to a line dropped from the fore part of the nostril. The angular disappears, as usual, between the splenial and dentary, not between the splenial and surangular. The splenials contribute a small proportion to the mandibular symphysis (Tab. XXI, fig. 4, 32′).

The teeth (Tab. XX, fig. 8) conform in relative size and slenderness of crown with the slenderness of the bones wielding them. Those at the fore half of the jaws incline more backward than usual, and hardly assume a vertical position in the maxillary and post-mandibular regions. I have counted from sixty-five to seventy on each side of the

upper jaw, of which twenty-five, or thereabouts, are implanted in the maxillary. In the lower jaw there are about sixty teeth in each dentary (Tab. XXVIII, fig. 2, 33). A few detached teeth in a portion of a large *Ich. tenuirostris* from the Lias at Pyx Hill measure, each, 1 inch 4 lines, the enamelled crown being about a third of that length; the cement-clad root is 4 lines in diameter, rather thicker in proportion than in the smaller-sized specimens of the present species.

The vertebral column (Tab. XXVIII, fig. 1) agrees in general length with the characteristic shape of the head. In the best preserved specimens it is nearly four times the length of the skull.

I have counted 156 vertebræ in a well-preserved column of the large specimen from Pyx Hill; in this the pinnigerous part of the tail was two feet in length, and had been bent down in the burial and subsequent petrifaction of the Sea-dragon at almost a right angle to the trunk; this deflected part included sixty centrums, which seemed to be relatively somewhat shorter as well as narrower than those of the trunk. At the bent part of the column the margins of the terminal articular facets were slightly deflected, and markedly raised from the level of the sides of the centrum, indicative of the degree and frequency of flexure at this part. The fore-and-aft diameter of a post-abdominal vertebra in an average-sized Tenuirostral is 13 lines, the vertical diameter being 2 inches 6 lines. The terminal articular surfaces of the centrums are more uniformly concave than in the previously described species. I have not found in *Ich. tenuirostris* more than two hypapophyses at the fore part of the column, one wedged between the basioccipital and the atlas, the other between the atlas and axis. This more simple apparatus for fixing the immediate support of the skull suggests an accordance with the lighter and more slender character of that part. The centrums gradually increase in fore-and-aft dimensions to the pelvic region, and do not begin to decrease in size till about ten vertebræ beyond the part forming the base of the long caudal region.

The ribs soon become long and slender as they recede from the head, and increase in length to near the hind end of the abdomen; thence they shorten less gradually than usual. Forty-five pairs of the long and regularly-curved ribs show the external longitudinal groove.

The parial fins (Tab. XXVIII, figs. 4, 6) show a somewhat less disparity in the size of the pectorals and ventrals than obtains in *Ich. communis* and *Ich. intermedius*. Their framework has fewer and larger bones, and the fore paddle impresses one with its massive proportions compared with the vertebræ. The clavicles are relatively more slender than in *Ich. communis*, but of the usual form, diminishing at the two extremities. The scapula is relatively larger than in *Ich. intermedius*, and is thicker and more expanded at the humeral end; its fore border is moderately concave and longer than the hind one. The coracoid (ib., fig. 3, 52) has a broad neck supporting a large and thick scapulo-humeral articulation; it has a deep and narrow anterior notch, and a shallow posterior emargination. In a well-preserved specimen of the present species, in the Philosophical

Institution, Birmingham, the length of the coracoid is 4 inches 5 lines, and the breadth 3 inches; the length of the humerus of the same specimen is 3 inches 10 lines, the breadth of its distal end is 3 inches. The transverse diameter of the radius equals the antero-posterior diameter of the centrums of two of the parallel vertebræ; its anterior margin is notched. The ulna has a corresponding size, with a smaller anterior notch circumscribing with an apposed notch in the radius a roundish vacuity. These bones were anchylosed together and to the humerus in the Birmingham specimen. The 'manus' commences by three transversely oval carpals, of which the radial one is notched, as in the radius; but this character is not repeated, as in *Ich. acutirostris* and *Ich. platyodon*, in the next distal bone, nor is the radial digit bifurcate, as in *Ich. communis* and *Ich. intermedius.* There are but three series of digital bones, with a fourth shorter marginal series of smaller ossicles.

In the hind paddle (Tab. XXVIII, fig. 6) the femur, like the humerus, has a longer shaft than usual, and not so proportionally broad a distal end. The tibia is notched anteriorly like the radius, but not so deeply; the corresponding tarsal bone is more feebly emarginate. In this fin, also, there are but three series of digital ossicles.

In the Museum of the British Institution there is a skeleton of *Ich. tenuirostris*, thirteen feet in length: it is from the Lias of Lyme Regis, Dorsetshire. Evidences of the same species have also been obtained from the Lias of Stratford-on-Avon, of Bristol, of Street, Somersetshire, and at Barrow-on-Soar, Leicestershire.

k. Ichthyosaurus longirostris, *Ow.* Tab. XXI, fig. 2; Tab. XXIV, fig. 3; Tab. XXVIII, figs. 7, 8, 9.

The specimens in the British Museum, from the Lias of Barrow-on-Soar, on which the present species is founded, and the least incomplete of which is the subject of figure 7, Tab. XXVIII, have borne the above specific name in the Public Gallery of the Department of Geology for fifteen years. The description was reserved for the present Work, and I regret the unavoidable circumstances which have delayed its publication.

Reckoning the lost terminal caudal vertebræ according to the guiding analogies I estimate the total length of the animal to include four lengths of the skull. Of this part the length of the rostral extension anterior to the orbit is four and a quarter times the antero-posterior diameter of that cavity: and yet the orbit is relatively larger than in *Ichthyosaurus tenuirostris.*

The teeth correspond in size with the slenderness of their supporting jaws; they are of difficult detection; the best preserved show crowns, as in fig. 9, Tab. XXVIII. With sufficient magnifying power traces of longitudinal striæ are discernible on the enamelled crown; the cemented base is as little tumid as in *Ich. tenuirostris.* In the relative

minuteness of the teeth of *Ich. longirostris* we may discern the transitional step to the edentulous Ichthyosaurs described by Prof. Marsh.[1]

I conclude that the present, together with other long- and slender-jawed Fish-lizards, may have preyed in a great degree upon the contemporary Cephalopods with internal rudimental shells as well as on Fishes. The eye in *Ich. longirostris* is proportionately large, like the orbit which the sclerotic circle almost occupies, suggestive of the nocturnal habits of the species; the plates seem to have been not fewer than sixteen in number. The present species, like *Ich. tenuirostris*, is characterised by the large size of the pectoral fin, and that of the ossicles representing the carpals and phalanges of its digits. These, however, are limited in number, as in *Ich. tenuirostris;* the three normal digits (II, III, IV) are instructively conserved, though not terminally entire, in fig. 7, Tab. XXVIII. The supplementary ossicles here preserved are, situated as in the tenuirostral species, along the ulnar margin, forming a sort of rudiment of the digit (V), which is normally developed in *Ich. communis* and *Ich. intermedius.*

The scapula, clavicle, and coracoid of the same side as the fin are definite, but dislocated. The coracoid repeats the type of that of *Ich. tenuirostris* so far as having the anterior notch the best marked, but the posterior one is more faintly indicated. The anterior notch (Tab. XXVIII, fig. 9) is placed further back, and becomes lateral rather than anterior. The articular prominence is also nearer the hind border of the lamelliform bone.

The radius and radio-carpal bone are notched anteriorly, as in *Ich. tenuirostris.*

The pelvic paddle has the same relative size as in that species, and the same tridactyle structure.

I reckon forty-eight vertebræ between the skull and pelvis; fifty-two vertebræ can be made out in the extent of the caudal region preserved; to which may be added about a score more for the wanting pinnigerous terminal portion of the tail, which probably has been torn off by predatory assailants of the dead reptile.

Besides the Liassic locality of Barrow-on-Soar, specimens and parts of *Ichthyosaurus longirostris* occur in the zone characterised by *Ægoceras angulatum;* also in the zone of *Arietites Bucklandi.*[2]

l. ICHTHYOSAURUS LATIMANUS, *Ow.*[3] Tab. XXIX, figs. 2, 7.

This species is nearly allied to *Ich. communis* in the size and construction of the

[1] "A New Order of Extinct Reptiles (SAURANODONTA)," 'Amer. Journ. of Science and Arts,' vol. xvii, Jan., 1879, p. 85.

[2] See the classical Monograph, by Dr. Wright, F.R.S., &c., in the volumes of the Palæontographical Society issued in 1878 and 1879.

[3] 'Report,' *ut supra* (1839), p. 123.

pectoral paddle; but the still smaller proportion of the pelvic one suggested the *nomen triviale*, which is vindicated, also, as a sign of specific difference, by the proportionally shorter and thicker jaws and by the modification of the vertebral centrums (Tab. XXIX, figs. 2 and 7); in this character the present species differs from *Ich. breviceps*.

Ich. latimanus resembles *Ich. communis* in the ventricose, subobtuse character of the teeth, or, at least, some of the more worn ones, of the twenty-nine which may be counted on each side of both jaws. The articular surfaces of the centrum are concave at the middle third, the rest of the surface to the circumference is flat.

In the specimen of *Ich. latimanus*, 6 feet 10 inches in length, and in that of an *Ich. communis*, 5 feet 2 inches in length, the following were the respective dimensions of bones of the scapular arch and its appendage:

	Ich. latimanus.			*Ich. communis.*	
	In.	Lines.		In.	Lines.
Scapula, length of	3	4	...	3	0
Coracoid, antero-posterior diameter .	3	8	...	2	4
Coracoid, transverse diameter . .	3	2	...	2	0
Antibrachials, breadth of . . .	2	5	...	1	7
Length of fore fin, humerus inclusive .	7	6	...	5	0
Breadth of ditto .	3	6	...	2	4

The clavicle is proportionally thicker than in *Ich. communis;* in the skeleton above cited it is 6 inches 8 lines in length.

The head is relatively shorter. In the specimen of which the dimensions are above given the mandible is 1 foot 4 inches in length, while in the *Ichthyosaurus communis* above compared it is 1 foot 5 inches in length.

In a specimen of *Ichthyosaurus latimanus* in the Museum of the Philosophical Institution at Bristol I counted 114 vertebræ; the terminal caudals showed in a greater degree than usual the compressed character indicative of the vertical tegumentary fin.

Parts of the carbonised integument are preserved on the slab of Lias on which lies the above skeleton; faint traces of integument lie above and beneath the deflected caudal vertebræ; a broad patch remains about four inches beyond the last preserved centrum, though not the last of the series. This is the sole direct evidence I have as yet detected of the tegumentary part of the tail-fin. Traces of the abdominal integument appear to be smoother than in the similarly preserved skin figured in Buckland's, 'Bridgewater Treatise.'

If, as has been suggested (p. 44), the pectoral arch and fin relate to occasional reptation on the sea-shore, it may be inferred, from the partial flattening of the articular surfaces of the vertebral centrums, as well as from their proportions, in the present species, characterised as it, also, is by more massive proportions of the pectoral arch and greater

relative size and strength of the fore paddles, that it was more littoral in its habits than the majority of these marine Saurians.

Saltford, near Bath, and the Penarth Beds (Rhœtic) of Glamorganshire are among the localities of *Ichthyosaurus latimanus*.

m. Ichthyosaurus brachyspondylus, *Ow.* Tab. XXIX, figs. 3—6.

This species is founded on vertebral characters, the centrums being shorter in proportion to their height and breadth than in any other that has come under my observation.

In the abdominal centrum, the subject of figures 3—5, Tab. XXIX, the breadth of the articular terminal surface (ib., fig. 4) is 2 inches 11 lines; the vertical diameter is 3 inches, while the antero-posterior extent does not exceed 11 lines. In a more posterior centrum (ib., fig. 6) in which the diapophysis (*d*) has descended to contact with the parapophysis, the same proportions are preserved with slight diminution of size. In a larger mid-dorsal centrum of this species which I examined in the private collection of Mr. Rose, of Swaffham, the breadth was 3 inches 8 lines, the height 3 inches 9 lines, but the length did not exceed 1 inch 5 lines.

In a collection of fossils from Mid-Jurassic beds in the Province of Moscow, submitted to me by Col. Kiprianoff, in 1853, were centrums showing the same dimensional characters, together with a low medial ridge dividing the under surface, which is, likewise, present in the British specimens. Col. Kiprianoff adopted the name, with my determination, of his Ichthyosaurian specimens, other evidences of which have since been detected and described in a valuable contribution to Russian palæontology by Prof. Trautschold.[1]

D. Conclusion.

Although a study of the evidences of Ichthyopterygian organisation, of which, and its modifications, as exemplified at the Liassic period, the results are given in the foregoing pages, has left the impression, mainly, of the great additions which wait to reward subsequent cultivators of this field of comparative osteology, I am unwilling to quit it without giving expression to some of the general notions which its cultivation has suggested.

Palæontology has been regarded, if not defined, as including a kind of knowledge of parts, or of structures, in such degree interdependent that, any one being given, others

[1] Trautschold (Prof. H.), 'Ergänzung zur Fauna des Russischen Jura,' 8vo, 1876, p. 5.

may be deduced as a necessary consequence, such deductions being determinative of the relations of the whole; so far as to give the Knower a power of predicating results, both zoologically, as respects the affinity of the otherwise unknown whole, of which only a part affects the senses, and physiologically, as respects the living powers of the whole and the part such extinct organism played in the sphere of its existence.

This necessary connection and interdependency of the links of structures constitute the essential condition and attractive character of palæontological science. The subjects, nevertheless, of the present Chapter, constrain me to submit the question, how far this science of ours has advanced towards sustaining the foregoing definition; in other words, to how much of organic Nature at large, or of particular organisms, it is so applicable?

Let us suppose, for example, that no other part of the petrified frame of an Ichthyosaur had come to our hands than had reached those of SCHEUCHZER or of BRONN,—a few vertebral centrums, for example, from the hind part of the trunk. Could we have otherwise concluded than they did? Certainly not, had our knowledge of the vertebral structures been restricted to the same parts of the extinct and fossilised animal.

Biconcavity of centrums is a pre-eminently piscine character, but not without exceptions in the class of Fishes, even in that great proportion of the species whose osseous development has advanced to individualised bony segments of the spinal column. Such an exception, *e. g.* we have in the opisthocœlian vertebræ of the Bony Gar (*Lepidosteus*).

But no known kind of Fish possesses vertebral centrums with both upper and lower transverse processes ('diapophyses' and 'parapophyses'). The presence of these in certain of the biconcave vertebræ of *Icthyosaurus*, bespeaks that of ribs having a two-fold articulation with their vertebræ; and such structure of rib implies a body-cage adapted to the movements of expansion and contraction of its cavity, which cavity we infer, therefore, to have contained bags receiving air, and to have had associated movements for the purposes of respiration.

But this function raises the exerciser above the grade of the Fish, and the next question of the Palæontologist would be, whether the air-breather was cold-blooded or warm-blooded?

The biconcavity of the vertebræ would sustain the first conclusion, and consequently a reference of the extinct animal, so fragmentarily indicated, to the Reptilian, not the Mammalian, class.

But what further insight into the nature of such Reptile could be gained by contemplation of a solitary centrum, or even of a series of vertebræ? With me no further step could be taken toward a sure knowledge of the nature of the cold-blooded air-breather, so partially indicated. A suspicion, at most, of an aquatic medium, and consequently of limb-structures adapted to locomotion therein, might have crossed the mind. But a complete reconstruction of the extinct animal, or certain knowledge of such, could only be the result of acquisition and comparison of the anatomy of the cranium, as well as of

the limbs and their sustaining arches; and such has been the knowledge supplied by the subjects of the foregoing pages of the present Chapter.

Here I may remark that instances of ancient extinct forms, manifesting a more generalised type, are more than ever worthy of note in the present phase of biological science; and the *Ichthyopterygia* contribute a welcome addition to this suggestive class of phenomena. In the construction of their chief natatory organ for forward movement may be discerned a combination of mammalian, saurian, and ichthyic conditions. In the great length and gradual diminution of the caudal series of vertebræ may be noted the saurian character; the tegumentary expansion, unsupported by bony rays, recalls the main feature of the cetaceous tail-fin, while its vertical position in the air-breathing Saurian brings it in close parallel relation with the corresponding natatory propeller in the class of Fishes.

Nevertheless, the Ichthyosaur, as an aquatic air-breather, might be supposed to have exchanged, at a loss, the disposition of its terminal fin in comparison with its aquatic warm-blooded, fish-like successors; but the pair of pelvic fins, wanting in all Cetaceans, are superadded to the locomotive instruments in the Ichthyosaurs, and were, doubtless, actively applied to bring the nostrils, when needed, within range of the superaqueous atmosphere.

But in almost every extinct natural group of animals peculiar conditions present themselves. In no known cold-blooded Fishes was the visual organ so well, or so conspicuously adapted to the detection of the finny prey as in our present subjects. To unusual size of eyeball, which in Dr. Buckland's experience sometimes reached that of a man's head, was added a circle of concomitantly large bones—the 'sclerotic plates'—of form and structure in harmony with the requirements of the visual outlooks. Was a near object to be detected, the retraction of the bony circle and contraction of its aperture, surrounded by the laterally overlapping plates, would coincide with a concomitant convexity of the cornea pressed upon by the squeezed humours within and with the contraction of the pupil—conditions concurring in the needed microscopic application of the eye. If the distant expanse of waters was to be scanned, the resumption of the normal position of the sclerotic ring and of the relaxed relations of the overlapping plates would coincide with an expansion of the pupil and flattening of the cornea, whereby the eye would thus acquire a telescopic range. Moreover, the wide transparent corneal aperture of the conspicuously large organ of vision would enable the predatory Saurian to take advatage of the least amount of light penetrating the depths of its marine environment.

THE

FOSSIL REPTILIA OF THE LIASSIC FORMATIONS.

CHAPTER III. Order—DINOSAURIA, *Owen.*

Genus—Scelidosaurus, *Owen.*

In the year 1858 a few fragmentary fossils of limb-bones were submitted to my inspection by James Harrison, Esq., of Charmouth, Dorsetshire, obtained from the upper part of the "lower Lias," near that place. They included portions of a femur and of a tibia, in which the texture of the wall and the size of the cavity of the shaft showed them to have been parts of a Saurian of more terrestrial habits than any of those which had been previously discovered in those liassic deposits: traces, moreover, of the extent and direction of certain processes, although broken away in the fossils, were discernible, which led me to suspect they belonged to a reptile allied to *Iguanodon.* I therefore briefly notified the fact of a liassic Dinosaur in my 'Palæontology,'[1] and indicated the animal by the generic name *Scelidosaurus.*[2]

The femur of the *Iguanodon*, as shown in vol i, p. 310, vol. ii, Pl. 20, is characterised by the deep and narrow fissure dividing a compressed external trochanter from the head of the bone, and by a process from the middle of the shaft, on the inner side, opposite to the part where the "third trochanter" projects in some of the large herbivorous mammals (*Perissodactyla*). Both these characters were repeated in the specimen of the shaft of the femur first submitted to me; but the shaft, viewed sideways, showed a more decided sigmoid flexure than in the Iguanodon, and the fissure between the great trochanter and the

[1] 8vo. ed., 1860, p. 258.

[2] Gr., σκελὶς, *limb*, σαυρος, *lizard;* from the indications of greater power in the hind legs than in most Saurians.

proximal end of the bone was relatively deeper. This end, divided by the cleft from the great trochanter, was subcompressed from side to side below the swelling out of the head, which had been broken or abraded away, showing a fine cancellous structure at that part. The antero-posterior diameter of this part is 6 inches; the transverse diameter, opposite the base of the outer trochanter, is 3 inches 8 lines.

The fore part of the shaft showed at its upper half a flattened, oblong, rather rough surface for muscular implantation. Below, and on the outer side of this surface, was a rough, roundish, slightly prominent tuberosity (*s*), continued at its inner side into a ridge, which descends with a slight curve outwards on the fore part of the middle of the shaft of the femur, where it terminates in a point at *v*. These risings indicated the force of the large muscles acting upon the limb, and by their insertions raising and drawing forward the femur. Behind the base of the process was a large, oblong, rough ridge indicating the extension of the surface of attachment, behind and beyond the process itself, for a powerful muscle depressing and drawing back the femur. From the great trochanter a narrow, rough surface, not projecting as a ridge, extended nearly straight down the outer and back part of the shaft. Exterior to this surface was an oval foramen, most probably for the passage of the blood-vessels and nerve to the medullary cavity.

The transverse section of the middle of the shaft is nearly circular; the thickness of the compact wall of the medullary cavity is here about one sixth of the transverse diameter of the bone. I have not seen a bone of any other Dinosaur indicative of more vigorous action of the hind limbs than the present femoral shaft.

The foregoing instructive fossil was accompanied by the shaft of a tibia of corresponding size, crushed and broken at both ends; it measured 18 inches in length and 2 inches 8 lines in diameter at its middle, the circumference of the shaft there being 10 inches.

These proportions indicated a hind leg, longer and more slender, relatively to the trunk, than in the *Megalosaur*, *Iguanodon*, or other Dinosaur with which such comparison may be made. The bone being fractured across the middle of the shaft, shows a large medullary cavity; the compact, bony wall does not exceed 3 lines in thickness, the cavity itself being 1 inch 3 lines in diameter.

At the proximal end the antero-posterior expansion and its ridges have been broken away. The bone gradually contracts, as it descends, to a subtriedral shaft, with a triangular transverse section, two of the angles being rounded off, and the third remaining, which was opposite the fibula. The distal expansion has been, in like manner, broken away; but its commencement shows the rise of an anterior ridge in addition to the fibular one. I shortly after received from

Mr. Harrison the lower half of a right femur and the upper half of the right tibia and fibula, cemented by the matrix in the natural relative position in which they enter into the formation of the knee-joint, when bent. This remarkable specimen indicates the tranquil state of the sea-bed or bottom after it had received the dead carcass of the Dinosaur. No agitation or other external violence had displaced the bones of the leg after the solution of the ligaments which tied them together in the living animal; when the depth to which they had sunk, and the consistency of the mud or clay bed, tended to retain them in their natural position. The portion of femur preserved indicates a slight backward bend of the shaft, which at the fractured part—probably a little below the middle of the bone—presents an almost circular transverse section. The circumference here is 10 inches; the compact wall of the bone is 6 lines thick; the medullary cavity 2 inches in diameter. A little below the fractured end, and 8 inches above the lower end, the shaft shows the termination of the characteristic inner process. From this point the femur expands gradually, and chiefly in the transverse direction. Posteriorly it becomes impressed by the popliteal cavity, which deepens and widens to the upper and back part of the inner condyle; which, by its production towards the outer condyle, contracts the lower end of the popliteal cavity transversely. On the outer side of the distal expansion of the femur the external wall is in part broken away; but a shallow and narrow longitudinal impression is indicated, terminating below in a rather shallow notch, which marks out the inner and hinder part of the outer condyle from the outer part of the same condyle. This notch corresponds with that between the tibia and fibula, and defines the portions of the outer condyle assigned to those bones respectively. The inner condyle is rather flattened on the inner side. The tibia is much expanded at the proximal end, chiefly by an extension of the bone forward; it is slightly convex on the inner or tibial side; a longitudinal prominence extends from the fibular side of the expansion, near the fore part, answering to the ectocnemial process in the bird's tibia; the main expansion forms the procnemial process which has subsided to the ordinary level of the shaft about six inches down the bone. The back part of the proximal end of the tibia presents two almost hemispheric protuberances, side by side; they might be mistaken in a detached bone for the backwardly projecting condyles of a femur, but are less deeply severed. The outer tuberosity articulates with a slight depression in the contiguous part of the fibula. The fore part of the proximal portion of the tibia is, transversely, concave, exterior to the pro- and ectocnemial processes. The fractured part of the shaft, eleven inches below the knee-joint, presents a full, oval section, with the same proportion of compact bony wall to medullary cavity as in the femur; the white spar filling the cavity contrasts strongly with the jet-black colour of the petrified bone. The

transverse diameter of this part of the shaft is 2 inches 3 lines; the fore-and-aft diameter is 2 inches 6 lines.

The fibula expands chiefly in the fore-and-aft direction at its upper end, where it measures 5 inches across. Six inches lower down this diameter has contracted to one of 1 inch 8 lines; eleven inches lower it measures 1 inch 3 lines, the transverse diameter being 9 lines. Seven inches from the proximal end the fibula presents at its outer and back part a thick, longitudinal, rough ridge, for the attachment of a muscle. It continues in contact with, and gets rather behind, the tibia as it descends.

The foregoing indications of a Dinosaur in the lower Lias excited speculation as to whether it had been herbivorous, like the Iguanodon of the newer Mezozoic beds, or carnivorous, like the Megalosaur, which has been traced from Wealden down to the Great Oolite. The structure of the femur pointed the former way, but the proof which the dentition only could give was wanting.

The persevering encouragement afforded by Mr. Harrison to the workmen in the Lias quarries was subsequently rewarded by the acquisition of the fine specimen of a skull which forms the subject of Plates 45, 46, 47.

The teeth, in their close-set, thecodont implantation, relative size to the jaw, degree of expansion, and general shape of the crown, resemble those ascribed to the *Hylæosaurus* (Vol. i, p. 367, Pl. 39); but the crown presents the median longitudinal prominence and marginal serrations which bring it closer to the Iguanodont pattern; and, in the degree in which they depart therefrom, they still more closely resemble the teeth of the *Echinodon* from the Purbeck, which may prove to be a small kind, or young, of a Dinosaur. They, however, present different proportions.

Referring, therefore, the skull in question to the Dinosaurian order, it supplies most acceptable information as to the cranial structure of that group, in addition to that derived from the *Iguanodon Foxii* of the Wealden beds (Vol. i, p. 520, pl. 49, figs. 9, 10).

Of *Megalosaurus*, and *Hylæosaurus*, portions of lower jaw, and fragments of the upper jaw, palate, and basis cranii, are all that have hitherto come to light. But the present specimen is the entire skull, wanting only the fore end of the upper and lower jaws.

The cranium has been slightly crushed and distorted by oblique pressure, due to movements of the matrix after imbedding and petrifaction. The right halves of the mid-frontal and nasal are depressed a little below the level of the left halves of the same bones, and the right diverging branch of the parietal has been broken from the rest of the bone, near the median line, and dislocated by the same pressure from its union with the mastoid. The right ramus of the

mandible, accompanying the movement of that side of the head, has been pushed so far below the left ramus as to have its inner side brought into view below that of the left side of the skull.

The occipital conforms to the Lacertian type (Pl. 60, fig. 2, 4), in the proportions and direction of the par-occipital; this process is long, narrow, straight, directed outwards, compressed from before backward, and slightly expanded at the extremity, which is applied to the back part of the mastoid and tympanic at the junction of those bones. It has been slightly displaced, its end appearing on the left side at 4, Pl. 45, with matrix intervening between it and the tympanic (28). A part of the exoccipital which projects backward to contribute to the formation of the condyle is exposed near the mass of matrix, including the atlas vertebra and nuchal dermal bones.

The cranial part of the skull, posterior to the orbits, is shorter in proportion than in the lizards, and resembles, in this respect, that of the *Iguanodon* (Pl. 49, fig. 9) and crocodiles. The parietal is short, and bifurcate behind, as in lizards. The body of the bone, or part between the temporal fossæ, is subcompressed where it forms the smooth, concave, inner sides of those depressions, which do not meet above, but are separated by a narrow, flat tract; this might be converted into a ridge in older individuals. The fore part of the parietal slightly expands where it is overlapped by the frontals. Each hind branch of the parietal extends outward and a little backward; its pointed end is obliquely overlapped anteriorly by the mesial branch of the mastoid, completing therewith the hind boundary of the temporal fossa. The crushed and dislocated state of the calvarium along its middle line does not permit the usual evidence of a foramen parietale to be detected, but the appearances are against such perforation being present. This foramen is not constant in modern lizards; the *Scelidosaurus* may agree with *Cyclodus* and *Tejus* in this respect. The parietal bone, as a whole, plainly accords with the lacertian, not with the crocodilian, type of that bone.

The mastoid (8) is a triradiate bone, forming the upper and hinder angle of the cranium, from which one ray passes mesiad to join the parietal (7), a second ray forward to join the post-frontal (Pl. 46, 12), and a third ray downward (Pl. 45, 8), to join the tympanic (28). A fracture of the body of the mastoid, by which he anterior branch is broken away on the left side, exposes a cancellous cavity, probably forming part of the organ of hearing.

The two halves of the mid-frontal (Pl. 47, 11) have been separated along the medial line, and the right half depressed. The separation appears to have been at a suture, as is certainly the case with the nasal bones; the medial margin of three fourths of the left frontal show the jagged, sutural character. I conclude, therefore, that the mid-frontal was divided, as in *Iguanodon* (Pl. 49, fig. 9, 11), and as in *Varanus* and *Lacerta* proper; and that it was not a single bone, as in

the Iguana and most *Lacertilia*, and as it is in the *Crocodilia*. Each half of the frontal in *Scelidosaurus* is a long, inequilateral triangle, the medial being the longest side, the posterior, which joins the parietal, the shortest; the antero-external border is irregularly and deeply notched, uniting with the post-frontal, super-orbital, pre-frontal, and nasal bones; it is excluded, as in *Lacerta* proper, by the large super-orbital bone (71) from the orbit. The outer surface of the frontal is sculptured by irregular lines and grooves, but less deeply than in *Crocodilus*.

The post-frontal (12) forms the back and part of the upper border of the orbit, uniting with the super-orbital, the frontal, and malar, and sending backward an angular process to join the mastoid, completing the upper bar or zygomatic arch of the temporal fossa. This arch had been broken away on the left side (Pl. 45), but is preserved on the right side (Pl. 46, 8, 12).

The pre-frontal (Pls. 45, 46, 14) presents a horizontal and a vertical portion; the former and larger part is wedged between the frontal, super-orbital, and nasal bones, the descending plate joins the lacrymal (73), and touches the upper angle of the maxillary (21). In the Crocodile the aspect of the whole outer plate of the pre-frontal is upward; in some Lacertians the major part looks outward.

The nasal bones (15, Pls. 46, 47) unite above and behind with the frontal (11) by a short border, obliquely and irregularly cut, to include the pointed anterior ends of the lateral halves of the frontal; the nasals expand as they advance, in union, first, with the pre-frontals, then with the maxillaries, where they slightly decrease in breadth. The outer plate of the nasals looks upward; the maxillary border is slightly bent down (15, fig. 2, Pl. 46), and is overlapped by the maxillary (21, ib.). The mutilated fore part of the skull precludes the determination of the relations of the nasals with the pre-maxillary, and of the character of that bone; but it most probably repeated, in the main, the conditions which it presents in Iguanodon.[1]

The fracture shows the superior thickness of the median and lateral borders of the nasals, the intervening part being, as it were, channeled below for the air-passage; this has not here been divided by any ossified vertical septum; the thickened palatal and alveolar parts of the maxillary, as they bend toward each other, present a convexity transversely to the nasal passage. This is closed below, as it seems, by the vomer (Pl. 46, fig. 2, 13).

Of the hind part of the bony palate the pterygoid was brought into view by removing the matrix between the diverging rami of the mandible. The body of the bone is in the form of a subtriangular plate, of 1 inch 7 lines extent along its mesial border, which is slightly concave, receding from its fellow at the medial line, or base, as in the Iguana; the apex extends outward, and a little downward to abut against the fore and inner part of the ectopterygoid. From the hind

[1] Vol. i, p. 521, pl. 49, figs. 9, 22.

border near the base a long and narrow process is sent off to abut against the tympanic. There is no trace of teeth on the pterygoid, as in the recent Iguanas; the higher type of Saurian dentition is retained in *Scelidosaurus* as in *Iguanodon* (Pl. 60, fig. 5, 20, 24).

The hind and probably main part of the maxillary, here preserved, is chiefly remarkable for the horizontal ridge which nearly equally divides the outer or facial plate of the bone into an upper and lower facet; and this ridge is continued a little way below the orbit upon the malar bone. It corresponds with the more strongly marked ridge in *Ptychognathus* and *Oudenodon*.[1] There is a lower and slighter longitudinal prominence of the maxillary along the outer alveolar plate. The maxillary reaches back beyond the middle of the orbit, from which it is separated, as in other Saurians, by the malar and lacrymal bones.

On both sides there is a small, unossified space between the maxillary and lacrymal; this corresponds with the larger vacuity in that part of the bones of the face in the Pterodactyle, which is reduced to the present proportions in some Teleosaurs, and becomes the functional nostril in the Ichthyosaur; but I believe that the true external nostrils of *Scelidosaurus* were included in the fore part of the skull which has been broken away, and were, as in the Teleosaur, distinct from the maxillo-lacrymal vacuities.

The orbits of *Scelidosaurus* are subcircular, almost vertical, looking outward. Were the super-orbital ossicle in *Crocodilia* enlarged and fixed by suture in the upper scoop of the orbit, it would give a less vertical outlook to the eye than it usually presents, especially in the skull of a crocodile from which that ossicle has been removed. But the composition of the rim of the orbit in *Scelidosaurus* is open to other homologies. The bone (71) may be compared with that wedged into the upper and back part of the orbit in some lizards, between the frontal and post-frontal, and by Cuvier regarded as a dismemberment of the latter element; only in *Scelidosaurus* it is extended forward to the pre-frontal, excluding the frontal from the orbit. In *Ichthyosaurus* the post-frontal has a forward extension to junction with the pre-frontal; it also passes backward to join the mastoid, leaving to the bone at the back of the orbit (Pl. 20, fig. 1, 12) a simple post-orbital function. In *Scelidosaurus* the bone which joins the mastoid sends down a post-orbital bar (Pl. 46, 12) to join the malar (ib. 26). The post-frontal holds the same relations to the orbit in *Iguanodon* (vol. i, p 521, Pl. 49, fig. 9, 12). In both genera there is a masto-post-frontal zygoma, as well as the ordinary malo-squamosal one. But the intervening space is not walled over by a supplementary plate as in *Ichthyosaurus* (Pl. 20, fig. 1, 27[1])

The delicate lacrymal bone (Pls. 45, 46, 73) appears to have been

[1] 'Description of the Fossil Remains of the Reptilia of South Africa,' 4th, 1876, vol. i, pp. 48—56; vol. ii, pls. xlv, lv.

fractured on the left side; on the right side it is entire. The malar bone (26) begins anteriorly, in a pointed form, between the lacrymal and maxillary, increases in depth as it extends beneath the orbit, sends up a process which bifurcates to receive the point of the post-frontal in the cleft, and extends backward and downward as a slightly convex and somewhat roughened plate, which articulates by its lower convex, but somewhat irregular, border with the squamosal (27). The posterior border of the malar presents a regular and well-defined, concave curve. The chief peculiarity of the bone is its unusual vertical extent posteriorly. The squamosal (Pls. 45, 46, 27) articulates with the lower border of the malar, and expands to be articulated with the outer part of the lower half of the tympanic (ib. 28). This deep and powerful arch of bone, answering to the zygoma in mammals, afforded attachment to large, masseteric muscles operating upon the lower jaw. Similar muscles may have been extended between the ridges of the upper and lower jaws.

The tympanic (partly exposed in Pl. 45, 28) is a long bone, compressed from before backward, almost vertical in position, with a slight forward bend, but firmly wedged between the mastoid and par-occipital above and between the squamosal and pterygoid below. The back part of the tympanic is convex transversely at its inner half, concave at its outer half, where the margin is slightly produced to join the upper part of the squamosal; the inner part of the tympanic is more extended where it is overlapped or abutted on by the pterygoid. Below this expansion the tympanic becomes contracted and thickened, forming a kind of neck to the transversely extended convex terminal condyle.

In the vertical position and length of the tympanic, *Scelidosaurus* resembles the *Lacertia;* in its fixity and extent of its connections it resembles the *Crocodilia.*

The lower jaw includes in each ramus an articular (29), a surangular (30), a coronoid (30′), an angular (31), a splenial (32), and a dentary (33) piece.

The articular (Pl. 47, fig. 2, 29) is situated in the inner side of the surangular (Pl. 45, 30), and is thickened and projects inward to form the cavity for the major part of the tympanic condyle, the outer border of which rests on the surangular. This element, convex externally, presents a longitudinal ridge near its upper part, which rises to join the posterior angle of the dentary element in forming a low coronoid process. The angular (ib. 31) does not extend beyond the surangular, but makes with it the angle of the lower jaw; it grows in vertical extent as it advances, is convex externally, unites with the dentary, and sends forward from its lower part a pointed process between the dentary and splenial elements. The splenial (Pl. 46, 32) makes a small appearance on the outer side of the ramus, between the angular and dentary (33), but is chiefly visible as a broad, smooth plate (Pl. 47, fig. 2, 32), applied to the inner side of the dentary. The

dentary (Pls. 45, 46, 33) is a very powerful bone, with the outer surface divided into an upper and lower facet by a longitudinal ridge paralleling that of the upper jaw. The ridge, commencing near the base of the coronoid process, descends, describing a slight curve to the middle of the outer surface of the dentary. Below the ridge the bone is convex, above it is concave; the lower facet has the kind and degree of roughness observable on the exposed surface of most of the cranial bones; the upper facet has a smoother surface, corresponding in that respect with the surface below the ridge of the maxillary.

The foregoing character of the lower jaw has, hitherto, been observed only in a fossil one, which has been referred to the Dinosaurian order; by Mantell,[1] originally to *Iguanodon*, and afterwards, when it had been shown to be more probably part of the *Hylæosaurus*,[2] to a genus which he called *Regnosaurus*.[3] In this specimen the outer surface of the dentary is divided into an upper and lower facet by a longitudinal ridge, which, commencing near the upper margin, probably at the base of a coronoid rising, descends as it advances to midway between the upper and lower border. It is, however, more obtuse than in *Scelidosaurus*, but the upper facet presents a like smoothness and vertical concavity.[4] In size the specimens closely correspond, and also in the close arrangement of the series of teeth. But these were relatively smaller and more numerous in the Wealden fossil; for whereas in *Hylæosaurus* ten teeth, or their sockets, occupy an extent of 1 inch 8 lines of the alveolar border, the same extent includes only seven and a half teeth or sockets in *Scelidosaurus*. In this genus, moreover, the ramus of the mandible presents a curve convex downwards, to about the same degree as the opposite curve is presented by the corresponding part of the jaw of *Hylæosaurus*. in which this peculiar bend is noticed in Vol. i, p. 366. In the mandible of *Scelidosaurus* a ridge, corresponding, perhaps, to the lower ridge in *Hylæosaurus*, is situated further back and higher up upon the surangular; and the facet, concave vertically between the lower ridge and the beginning of the upper ridge, is peculiar to the mandibular fragment referred to the *Hylæosaurus*. Thus, with corresponding Dinosaurian character, imparting robust strength to the mandible, there are well-marked generic distinctions in the specimens here compared, both in the conformation of the jaws and teeth.

The mandibular rami of *Scelidosaurus* describe a slight sigmoid curve from the angle forward, horizontally, at first concave, then convex, towards the median line, where they meet without blending at the part fractured. It is not probable that the symphysis would be much prolonged beyond this point. The degree of convergence of the contour lines of the whole skull, both median and lateral, with

[1] 'Wonders of Geology,' 1838, vol. i, p. 393.

[2] "Report on British Fossil Reptiles," 'Trans. of Brit. Association,' 1841, p. 120.

[3] 'Philos. Trans.,' 1848.

[4] Vol. ii, pl. 39, fig. 1.

the decreasing size of the anterior teeth, makes it more probable that but a small proportion of the muzzle is wanting in the present specimen.

Removal of matrix from the hinder interspace of the mandibular rami exposed a ceratohyal, 3 inches in length, 4 lines in breadth, of a slight sigmoid flexure, the hind part bending up to between the angle of the mandible and the atlas vertebra; as no trace of basihyal was found, this element was probably cartilaginous, like that broad one in the tongue-skeleton of the crocodile.[1]

The specimen of *Scelidosaurus* here described has been buried and petrified with the mouth shut; there has been no dislocation of the under jaw, and the skull shows that the teeth of the upper jaw overlapped and concealed those of the lower. The crowns of both series were a little inclined inward, as shown at the fractured fore part (Pl. 46, fig. 2, *a b*,); there is a similar inclination of the alveolar plates.

The teeth are small, or of Lacertian proportions to the jaws; they are numerous and close-set, implanted in sockets (ib. *a*) forming an uninterrupted series along the alveolar border. The fang is simple, and longer than the crown, presenting a full ellipse in transverse section, and projecting a little beyond the socket. In the upper jaw the crown (Pl. 46, fig. 3, magn.,) begins by bulging outward, with a smooth convexity subsiding as it gradually expands, and dividing to be continued along the middle and the margins, with intervening concavities, producing an undulated surface across the broadest part of the crown. The marginal convexities or ridges terminate each in a point at the broadest part of the crown; whence, the plate-shaped tooth having thinned off to an edge, this is divided on each side into five or six smaller points; these denticulate margins converge straight, at an angle rather less than a right one, to the apex of the tooth, which is formed by the pointed termination of the median convexity. The crown is coated by a polished enamel, of jet blackness in the fossil, smooth under the lens upon the convexities, finely punctate in the hollows of the expanded part of the crown. The whole tooth in the upper jaw is very slightly bent backward, with as slight an oblique twist, making the hinder angle overlap, in some, the front angle of the crown of the tooth behind.

The inner surface of the hind teeth exposed in the right ramus of the jaw (Pl. 47, fig. 2) shows similar configuration of the crown to that of the outer surface of the teeth above; but with a larger proportion of the serrated part, and with the borders less equal, the anterior one showing as many as nine points.

On the left side, in an extent of the alveolar border of the upper jaw measuring 4 inches, there are nineteen sockets, and only one tooth missing. On the right side, in an extent of $3\frac{1}{2}$ inches, there are sixteen sockets, and three teeth missing. The fractured part of the jaw yields evidence of the usual

[1] 'Archetype of Vertebrate Skeleton,' 8vo, 1848, p. 121, fig. 22, 40.

reptilian provision for successional teeth in reserve alveoli, containing tooth-germs, at the inner side of the base of the teeth in place (Pl. 46, fig. 2, *c*). The teeth gradually increase in size from the hindmost to the fifth in advance, continue of about the same size to the tenth, and then gradually decrease in size to fractured fore part of the jaw.

Were the serrated borders of the terminal half of the crown to be worn down, the teeth of *Scelidosaurus* would be like those referred to *Hylæosaurus* in Vol. i, p. 377, Vol. ii, Pl. 39. There is no evidence, however, that any of them have been so worn down; in this respect they resemble more the teeth of *Echinodon*, the upper teeth in *Scelidosaurus* differing chiefly in the proportions of length to breadth of the crown. Whether the anterior teeth had the simple laniariform character at the fore part of the jaws in *Scelidosaurus*, as in *Iguanodon* and *Echinodon*, remains to be proved. The finely and sharply serrated and pointed teeth of the *Scelidosaurus* glided upon each other, the upper on the outer side of the under, like the blade-shaped crowns of the carnassials of feline mammals; and yet the similarity of the teeth, in their number and uniformly small size, to those of the modern Iguanas suggests that they may have been put to like uses. The compressed, serrate crowns in those herbivorous lizards worked obliquely upon each other, in a similar scissor-blade way. In *Iguanodon* the dentition is obviously modified more decidedly for mastication of vegetable substances. In *Scelidosaurus* it is adapted for division of such substances, but it would be equally effective in piercing and cutting or tearing through animal textures.

If this Dinosaur occasionally went to sea in quest of food, it may be expected to present in the fore part of the jaws, wanting in the present specimen, laniariform teeth, as in Iguanodon (Pl. 49, fig. 9, *i*), for the prehension and retention of living prey. Should these prove to be absent, and the dental series to begin as it ends, it will incline the balance of probability to the phytophagous nature of the Liassic *Scelidosaurus*.

Following in the track opened out by the discovery of the skull, about twelve successive blocks of Lias were secured, with more or less evident indications of included bones, all of which, together with the skull, were secured and transmitted to the British Museum. Subsequent complete exposure of the included organic remains has brought to light the entire vertebral column of the trunk and tail, to very near the termination of the latter; the scapulo-coracoid arch and part of one fore limb being associated with the thorax, and the iliac bones and both hind limbs with the sacrum: all were parts of the same individual Dinosaur.

In the operation of clearing off the matrix, scattered dermal bones first presented themselves, and these were removed, with a note of their position, when it became plain that they did not touch or rest upon any part of the endo-skeleton. This

being reached, the dermal bones in contact with it were left, save where they concealed some joint, process, or other light-giving or characteristic part of the framework. In the course of these operations it soon became evident that the whole vertebral column, in a series of consecutive and but slightly disturbed and mostly coarticulated segments, from the axis to the thirty-fourth caudal vertebræ inclusive, had been raised from their place of deposit; all the parts, save the centrum and a small and low coalesced neural arch, having ceased to be developed, in the terminal caudal vertebræ, the last of which in the recovered series was reduced to dimensions so small as to indicate that but very few remained to complete the tail of the Scelidosaur. The first vertebra of the neck was adherent to the back part of the skull above described.

Of the liassic masses following that which included the skull the first four contained twenty vertebræ, extending from the axis to the mass including the sacrum, and they were clearly consecutive save at one part of the neck.

The back part of the mass containing the skull includes the atlas vertebra in connection with the occiput, and surmounted by a pair of dermal bones (Pl. 48, fig. 1, *dn*). The block which fits to the fractured surface including the body and the neurapophyses of the atlas contains the axis and third cervical vertebra. The next piece revealed one nearly entire cervical vertebra (ib., figs. 3 and 4) and part of a second vertebra. The third, larger, piece included ten coarticulated vertebræ (Pls. 49, 50), but the continuity of the fore part of this mass with the last mentioned could not be clearly made out. The fourth block fits to that containing the ten dorsals, and included the five consecutive vertebræ with part of a sixth (Pl. 51). The block which contains the sacrum has also two vertebræ in advance of it (Pl. 53), part of the first of which lies in the preceding block.

Thus there was evidence of at least twenty-two "true" vertebræ; but there may have been one or two vertebræ from the region of the neck which had not been recovered. The vertebra attached to the first sacral seems not to have supported ribs: the one in front of it has a pair of long, freely articulated ribs, and may be reckoned the last dorsal. Including this, there may be assigned sixteen vertebræ to the dorsal series, if we include therein the ten vertebræ in Pl. 49, leaving six or seven to the cervical series. The lumbar series seems thus reduced to one vertebra. The sacrum includes four vertebræ. Of the caudal series thirty-five vertebræ were preserved, in five consecutively fitting blocks of matrix, leaving parts of two terminal ones, so small and simple as to show that very few are wanting in the present fossil skeleton.

The modifications of the spinal column of the trunk and tail of the Scelidosaur could thus be studied and compared in sixty consecutive vertebræ of one and the same individual.

The fracture of the matrix including the skull has passed through the cen-

trum (Pl. 48, fig 1, *c*), the hypapophysis (ib., *hy*), and the neurapophyses (ib. *n*, *n*), of the atlas.

The centrum of the atlas is small, and has been anchylosed with that of the axis (Pl. 48, fig. 2, *x*). Its vertical section is subquadrate, longitudinally grooved on each side; broader above than below. The hypapophysis (fig. 1, *hy*) is broader, but less deep, than the centrum, and the bases of the neurapophyses (ib., *n*, *n*,) extend down the sides of the centrum to articulate with the hypapophysis.

The neurapophyses (ib., *n*, *n*) are ununited above, as they are below, and have yielded to the oblique pressure; but the slight dislocation seems to have taken place without fracture of an upper union. There is no trace of spinous process; but above the neural arch of the atlas is a pair of large, thick, transversely oblong, dermal bones or scutes; the fractured surface of the most entire one, to the right (ib., *r*), is 2 inches in length by 1 in depth; it exposes a compact peripheral texture of 4 or 5 lines in thickness at the upper and outer part, and about 1 line at the under or inner part, with a fine cancellous structure between. To the broad hypapophysis of the atlas was articulated a long and slender rib (*pleurapophysis*) (ib., fig 2, *pl*, *a*).

In the foregoing constitution of the vertebral segment succeeding the skull we have the reptilian condition of the atlas, with modifications most closely repeated by the *Crocodilia* amongst the existing members of the class. The *Crocodilia* alone show the transverse extension of the hypapophysis or "pseudo-centrum" of the segment, associated with the presence of articulations for the pleurapophysial elements. In lizards free pleurapophyses are not developed from the atlas or from the axis, rarely from the third cervical vertebra. But in *Scelidosaurus* the atlantal hypapophysis is relatively broader than in *Crocodilia*, and there is no trace of the detached representative of the neural spine which characterises the atlas in Crocodilia.[1] In Plesiosaurus and Ichthyosaurus the true centrum of the atlas progressively acquires its form and proportions as such, and in the same degree resembles, in its relations to the basi-occipital, and to its own neural arch, the centrum of the first trunk-vertebra in fishes. The hypapophysis is proportionally reduced in size, and forms the first of the "sub-vertebral wedge-bones" in the *Ichthyosaurus*.[2]

The second block of Lias (Pl. 48, fig. 2) includes the bodies of the axis (*x*) and of the third cervical vertebra, with parts of the pleurapophyses of the atlas (*pl. a*) and axis (*pl. x*); it includes, also, large, massive, dermal bones external and superior to the vertebral elements. The centrum of the axis is 1 inch 3 lines in length, from the line of adhesion of that of the atlas, part of which remains connected as the "odontoid process;" the proper body of the axis is subcarinate

[1] 'Annals and Magazine of Natural History,' vol. xx, pp. 217—225.

[2] *Ichthyopterygia*, pl. xix, fig. 5, *hy*, *a*; pl. xxiii, fig. 2.

below; gently concave lengthwise at the sides; compressed in the same degree at the middle, and slightly expanded at the extremities. The rib which it supported (*pl' x*) is shorter than that of the atlas, but, like it, is slender and straight; about 3 inches of the atlantal rib is preserved, and about 2 inches of that of the axis.

The body of the third vertebra presents a general increase of size; it is 1 inch 8 lines in length, 2 inches 3 lines across the parapophyses at the fore part of the vertebra, 1 inch 6 lines across the posterior articular surface, and 1 inch 2 lines in depth. It is subcompressed at the sides, and more obtusely ridged below than the axis. The fore part of the body is articulated by an almost flattened surface with that at the back of the axis.

The characters of the terminal articular surfaces were worked out more completely in a consecutive cervical vertebra detached from the third block, and which, from its size, is probably the sixth. The part of the front surface (fig. 4, *b*) which is preserved is flat with a convex periphery; the hind surface (fig. 3, *c*) is slightly concave, with a narrower and better defined circumference. The body of this vertebra is 1 inch 10 lines in length, 2 inches 3 lines across the parapophyses (*p*); 1 inch 8 lines across the hinder articular end (*c*). The under part of the centrum presents near its fore end a hypapophysial tuberosity; it is constricted at the middle, and a small venous canal opens into that concavity on either side. The rib articulates by a bifurcate end with both par- and diapophyses; the upper transverse process (fig. 4, *d*) extends nearly $1\frac{1}{2}$ inch from the neural arch; the neural canal (*n*) is of a full oval form, with the small end downwards; it is 9 inches in its longest diameter. The breadth of the neural arch, below the diapophyses, is 1 inch 7 lines.

In the portion of the succeeding cervical vertebra, from the same block, the rib is directed more outwardly than in the antecedent one. The length of the neck of the rib is 1 inch 2 lines; its thickness 6 lines, which increases after the development of the tubercle, where the fracture shows a subtriedral section. The portion of the articular surface which is preserved of the centrum of the second vertebra indicates the same feeble concavity as in the preceding cervical vertebra (fig. 3).

Supposing the vertebra (Pl. 48. figs. 3 and 4) to be the sixth of the cervical series, it shows that the rib has more speedily resumed its normal character than in the *Crocodilia*. In these large existing Saurians the pleurapophysis, slender, straight and rather long, in the atlas and axis, becomes shortened and expanded in the third, fourth, fifth, and sixth cervical vertebræ, assuming in them a hatchet-like shape, with an overlapping arrangement; the posterior production of the "blade" lengthens in the seventh cervical; but the ordinary rib-shape is only resumed in the eighth vertebra, regarded as the first dorsal by Cuvier.

I infer, therefore, from the size and proportions of the two vertebræ just described that they correspond with the sixth and seventh in the Crocodile, and that the Scelidosaurus, with probably other *Dinosauria*, differed from *Crocodilia* and from most *Lacertilia* in the long and slender form of most, if not all, of the cervical ribs; but that these manifested their more essential Crocodilian affinity in their twofold articulation, by a bifurcate head, with distinct upper (*d*) and lower (*p*) transverse processes.

The fourth block included, with the scapular arch, ten of the anterior dorsal vertebræ (Pls. 49, 50). The hinder fracture of the block has detached the anterior articular surface from the eleventh dorsal, the rest of which is the first of the series of the five following dorsals in the fifth block of Lias (Pl. 52, figs. 1 and 2). The hinder fracture of this block has pretty equally bisected the last vertebra, which bears free ribs, viz. the sixteenth dorsal, the hinder half of which remains in the fore part of the block (Pl. 53), including the lumbar and sacral series of vertebræ. The section of the eleventh dorsal thus exposed near the anterior articular surface of the centrum is represented of the natural size in Pl. 52, fig. 1, D 11. That through the middle of the sixteenth dorsal vertebra is similarly represented in fig. 2, D 16.

The spinous process of the first dorsal vertebra (Pl. 45, D 1) is 1½ inch in height and 8 lines in fore-and-aft extent; the spine increases in both directions to the fifth of these vertebræ (5), which is 2 inches 4 lines in height and 1 inch 10 lines in basal extent. The spines continue of about the same height to the tenth vertebra, D 10, with summits obtusely rounded, almost truncate. In the eleventh to the sixteenth dorsals, Pl. 51, D 11—D 16, the spines acquire their greatest fore-and-aft extent, with truncate summits, but no increase of height. Although these spines in the last six vertebræ are nearly 2½ inches in antero-posterior extent, their summits do not come into contact, but leave interspaces of from 5 lines to 8 lines.

The prezygapophyses in the anterior dorsal vertebræ look inward and a little upward, the postzygapophyses in the reverse directions, but as the vertebræ recede in position the aspect of the surfaces becomes more nearly horizontal (Pl. 52, fig. 1 *z*). The diapophyses are subdepressed, 10 lines in breadth in the second vertebra, and gradually increasing to a terminal breadth of 15 lines in the ninth and tenth dorsals (Pl. 49, *d*, *d*). The parapophyses, as in the Crocodile, gradually pass from the centrum to the neural arch, and are seen at *p*, fig. 1, Pl. 51, upon the under and fore part of the diapophysis (*d*) in the eleventh of this series of dorsals, where the length of the diapophysis from the base of the neural spine is 2 inches 9 lines. No trace of parapophysis, or of the "head" of the rib, remains in the last three dorsals; the diapophysis is entire, as at *d*, fig. 2, Pl. 51.

The ribs of the twelve anterior dorsal vertebræ show both the head and the tubercle, the neck becoming gradually shorter in the last three. In the seventh

vertebra the extent of the rib from the head to the tubercle is 2 inches 9 lines. In the tenth vertebra it is 1 inch 7 lines. The rib presents a shallow canal along its posterior surface; it is nearly an inch in thickness. An extent of upwards of 10 inches of the body of the rib (*pl.*, Pl. 49) is preserved on the right side of this portion of the thorax of *Scelidotherium*.

The anterior dorsal vertebræ have been partially dislocated, especially the fourth from the fifth, apparently by pressure acting through the scapula (51) upon the diapophysis and spine of the fifth dorsal. Beyond the scapula the vertebræ have retained their natural position and connections, which seems to indicate the action of pressure whilst decomposition of the soft parts was going on in the carcass. Nine of the consecutive vertebræ in the fourth block occupy the extent of 1 foot 9 inches. The breadth of the last of these vertebra (Pl. 49, D 10), across the diapophyses (*d*), is 5 inches 4 lines. The total height of the eleventh dorsal vertebra (Pl. 52, fig. 1) is 6 inches. The breadth of the centrum at the fractured part, near the anterior surface, is 1 inch 6 lines. The depth of the centrum, from the floor of the neural canal, is 2 inches. The breadth of the neural arch across what are called the "pedicles" is 1 inch 8 lines. The height of the neural spine is 2 inches 6 lines.

As the vertebræ approach the sacrum the bodies gradually increase in depth, without gaining in breadth, until at the last dorsal the centrum, near its middle part, measures $2\frac{1}{2}$ inches in vertical and 1 inch 7 lines in transverse diameter; a slight longitudinal impression on each side produces the contour of the transverse vertical section figured in Pl. 52, fig. 2. The neural canal here gives a triangular section, with the apex downward and sinking into the substance of the centrum, but the sutural limit between centrum and neural arch are indiscernible. The diapophyses decrease in breadth and also in length, and now support the rib by a terminal, slightly notched, articular facet. The ribs, here with simple heads, become shorter and less curved; a few, as in Pl. 51, fig. 1, *pl*, have suffered fracture, with very little displacement. In different parts of the matrix of the blocks (Pls. 49 and 51) are portions of long and slender bones, which are, most probably, abdominal ribs.

In the sixth block the hinder half of the last dorsal and one lumbar vertebræ are associated with the pelvis; the lumbar vertebra (Pl. 53, L) had been dislocated downwards from its articulations with the sacrum.

The four vertebræ of this part (Pl. 53), with the iliac bones (62), are preserved almost in their natural relative positions, the sacral vertebræ having their neural spines and transverse processes exposed. Those of the first sacral (s, 1, *d, pl*) stand out horizontally and transverse to the axis of the body; a slight swelling (*d*), about one inch from their origin, may indicate the point of confluence of the pleurapophysial (*pl*) with the par- and diapophysial elements of this part. It is $4\frac{1}{2}$ inches in length; at its base it is 1 inch in thickness and 2 inches in depth, expanding in

that direction to fully 3 inches at the truncate extremity, and in breadth to 2 inches 2 lines. Towards its end the process is excavated anteriorly, so that the rough terminal surface (fig. 2, *pl.*) abutting upon the iliac bone is reniform. Fracture of an angle at this surface in the left transverse process shows a medullary cavity of 10 lines in diameter by 6 lines in the section as exposed, surrounded by a fine cancellous, almost compact, osseous texture, of from 2 lines to 4 lines in thickness.

The transverse processes of the other sacral vertebræ gradually become shorter, with corresponding decrease of breadth at their origin, but with equal or greater expansion of their termination, that of the last (*pl, s* 4) measuring 2 inches 7 lines in fore-and-aft breadth; the transverse processes thus touch each other, or nearly so, at their ends, and offer a continuous longitudinal surface for the ligamentous or fibro-cartilaginous attachments of the iliac bones (62). The total length of the articular "sacro-iliac" tract, so formed, is about 10 inches; a very slight lateral twist or dislocation makes it rather longer on the left than on the right side; this appears to have been due to great pressure after imbedding, and is accompanied by fracture or dislocation of the pleurapophysial part of the transverse process of the last two sacral vertebræ.

The spinous process, in each of the four sacrals, is about 2 inches high and 2 inches 3 lines in fore-and-aft extent; they touch each other by their rough, flattened summits; these are narrow anteriorly, gradually expanding to a breadth of 8 lines at their posterior third, with a thick, rounded termination; the position of these spines is over the interspaces of the origins of the transverse processes, through the backward inclination or extension of the neural arches. The articular processes are faintly indicated at their base, the posterior processes overlapping the anterior ones of the succeeding vertebra. The longitudinal extent of the truncated summits of the four sacral spines is 9 inches.

The hinder fractured surface of the block containing the sacrum exposes part of the first caudal vertebra, the rest being associated with the four consecutive caudals in the seventh block of Lias (Pl. 54, figs. 1 and 2).

The first caudal vertebra has been dislocated from the last sacral, and twisted half round, so that its spine lies upon the sacral transverse process; the fracture has passed through the spine and part of the neural arch. The length of this spine (Pl. 54, fig. 1, *ns*) from the upper part of the neural canal is 3 inches 6 lines, the transverse process (*d*) is 2 inches 3 lines in length, but its vertical thickness is reduced to 5 lines at 2 inches from its termination. The neural canal is 6 lines in breadth and 10 lines in depth. The bases of the neural arch seem to show that the anchylosis with the centrum had not here been complete.

The length of the first caudal centrum (Pl. 54, *c* 1) is 2 inches, the depth or vertical diameter of its articular end is 2 inches 5 lines; the surface is moderately

concave, with the circumference bevelled off convexly; between the two expanded ends the centrum is moderately and uniformly concave lengthwise. There is no trace of hæmal arch in the first caudal. In the second that arch (Pl. 54, fig. 2 *h*) is articulated to the posterior part of the under surface, and is produced into a spine of nearly 4 inches long. In the third caudal (ib., *h*, *c* 3) and succeeding ones the hæmal arch has been dislocated, showing its articular surface, which, by mutual union of the hæmapophysial bases, is single, sub-reniform, transversely extended, lightly concave across, and convex from above downward. The hæmal canal, thus circumscribed, and well shown in the fourth caudal vertebra, is about 2 lines in breadth and 1 inch 3 lines in length; too narrow, it would seem, for the protection of the trunks of the blood-vessels supplying so long and so powerful an organ as the tail of the *Scelidosaurus*. This form of the hæmal canal or slit has every appearance of being natural, and not due to any posthumous compression. The hæmapophysial surface external to it is convex transversely, slightly concave lengthwise; the laminæ slightly contract to their union in the spine, which becomes compressed, and a little expanded from before backwards near its termination. The articular surface, after the second hæmal arch, is afforded in equal proportions by the two conjoined centrums beneath their terminal junction. The transverse process of the second caudal (ib., *d*) arises from the anterior two thirds of the vertebra, over the junction of the centrum with the neural arch; a trace of the suture indicating the pleurapophysial character of this process is discernible in this and some following caudals. The length of the centrum is 2 inches 2 lines; the fore-and-aft breadth of the base of the transverse process is 1 inch 5 lines; its length is 2 inches 5 lines; its terminal breadth is 10 lines, ending obtusely. The transverse processes progressively decrease in all these dimensions in the following vertebræ. The anterior zygapophyses (Pl. 54, fig. 1, *z*) are twice the length of the posterior ones (*z'*), by which their extremities are overlapped. The fore-and-aft breadth of the neurapophyses between these processes is 1 inch 2 lines; that of the summit of the neural spine is 1 inch 6 lines; the height of the spine from the base of the prezygapophysis is 3 inches 4 lines. These dimensions are taken from the third caudal vertebra. The five consecutive and coarticulated anterior caudal vertebræ in the present block of Lias give a collective longitudinal extent of 12 inches. The distal half of the right femur (Pl. 54, fig. 2, 65), and parts of the right tibia (ib., 66) and fibula (ib., 67), are cemented to the vertebræ by the matrix. Figure 1 in this plate gives a side view, fig. 2 an oblique under view, of the first five caudal vertebræ.

The succeeding (eighth) block includes the five vertebræ (Pl. 55, fig. 1) next in succession. In these the length of the centrum continues to be a little over 2 inches, but they gradually decrease in other diameters, and especially in the size of their diverging parts. The neural spine, in the ninth, is reduced to 2 inches 5

lines in length; the transverse process (ib., fig. 1, *d*) to 1 inch 3 lines. The hæmal arch and spine retain a length of 3 inches 3 lines. That of the seventh vertebra (fig. 1, *h*) has a basal diameter of 1 inch 1 line, decreasing to 6 lines at the end of the neural canal, and thence to a terminal diameter of 2½ lines, the fore-and-aft diameter being here 10 lines. The centrums progressively become more concave and compressed between the articular ends. The prezygapophyses (ib., fig. 2, *z*) have their articular surface turned more inward, and grasp, as it were, the shortening rudiments of the postzygapophyses, the neural arch progressively contracting in breadth. The collective length of the five vertebræ in this block is 11 inches.

The ninth block of Lias contains the five succeeding caudals (Pl. 55, fig. 3). The centrums, exposed at their under and lateral parts, are singularly crushed, the sides of each having been pressed into the substance; yet, where the cracks of the matrix expose the texture of the centrum, as in the fifteenth caudal (Pl. 52, fig. 3), it shows a fine, compactly cancellous structure throughout; there is no trace of any such vacuity or unossified nucleus of the centrum as is met with in the vertebræ of *Poikilopleuron*, for example. The centrums retain their length of 2 inches. The hinder articular end of that of the tenth caudal (*c*) adheres to the fore part of the present block. In the next coarticulated vertebræ, which is the eleventh of the caudal series (Pl. 55, fig. 3, 11), the prezygapophysis (ib., fig. 4, *z*) is 10 lines in length and 3 lines in breadth; the neural spine, measured from the base of the zygapophysis, is 2 inches in length; the transverse process (fig. 3, *d*) is 1 inch in length, with half an inch of basal breadth. Nearly 2½ inches of the hæmal arch (ib., *h*) are preserved.

The pressure crushing the centrum of the eleventh vertebra has been applied to the middle of the under and lateral part; the articular ends have withstood, if they have received, it. The same is the case with the twelfth caudal. In the thirteenth the pressure has been more laterally applied, and the outer wall, which has been driven in, preserves its vertical convexity. The diapophysis of this vertebra is 10 lines in length. In the fifteenth caudal (ib., 15, *d*) the diapophysis is reduced to 6 lines in length, with corresponding decrease of thickness. The five caudal vertebræ from the eleventh to the fifteenth inclusive occupy a longitudinal extent of 11 inches 6 lines.

The tenth mass of Lias, fitting on to the foregoing, includes a consecutive series of nine vertebræ, viz. the sixteenth to the twenty-fourth caudal inclusive (Pl. 56, fig. 1). In this series there has been a dislocation of the eighteenth from the nineteenth, and a similar one between the twenty-first and the twenty-second vertebræ, with an interval of nearly an inch between the separated articular ends of the centrums. These elements continue to decrease in vertical and transverse diameters, and also, but in a minor degree, in regard to their

length. The transverse process has subsided to a tubercle upon the eighteenth (ib., fig. 1, *d*), and the postzygapophysis to a notch at the back part of the base of the neural spine, but the prezygapophysis (*z*) continues long and slender throughout this series. The neural spines progressively narrow and shorten, with a backward inclination. The base of the hæmal spine (*h*) of the sixteenth caudal measures 9 lines; its articular surface is transversely oblong. The surface for the articulation of the hæmal arch, from this part of the tail onward, is chiefly afforded by the hinder and under part of its own vertebra, as in fig. 3, *h*. The hæmal arch and spine becomes reduced in the eighteenth caudal to the length of its centrum; and in the twenty-third becomes shorter than the centrum, with a greater degree of antero-posterior expansion of the spine in proportion to the length of that part (ib., fig. 1, 23, *h*). The transverse diameter of the anterior articular surface of the nineteenth caudal is 1 inch 6 lines. The middle of the centrum has been reduced by pressure, attended with some fracture of the outer surface, to a diameter of 7 lines. In some of these vertebræ the middle, crushed parts of the centrum have been severed from the terminal articular expansions. I conclude, therefore, that they have been subjected to a general compressive force, probably connected with the change in the vertical relative position of the stratum. The compact layer of osseous tissue forming the articular end has resisted the pressure; the intervening, intermediate, cancellous structure has yielded to it.

From three smaller portions of the matrix, succeeding the ninth block, eleven consecutive caudal vertebræ were wrought out, as in Pl. 56, fig. 2, making us acquainted with a total of thirty-five caudal vertebræ of *Scelidosaurus*. In the last of this series the centrum (ib., 35) is reduced to the length of 1 inch, and the breadth of its front articular end to 6 lines. In the twenty-fifth caudal vertebra the centrum (ib., fig. 3) is 1 inch $10\frac{1}{2}$ lines in length, 1 inch 3 lines across the articular end, $7\frac{1}{2}$ lines across the middle, the longitudinal concavity of the sides exceeding that of the under surface. At the fore part of this surface the hæmapophysial articulation is barely indicated; at the back part it is marked by two surfaces (*h*), towards the most prominent part of which short, low ridges diverge. The low neural arch has coalesced with the upper three fourths of the centrum; the prezygapophyses (*z*) overhang the free fore part of the centrum, and extend beyond it to clasp the back part of the preposed neural spine. This is represented by a short, compressed ridge projecting above the part clasped by the prezygapophyses. The hæmal arch of the twenty-fourth caudal (ib., fig. 2, 24, *h*) underlies the centrum of the twenty-fifth; it presents a length of 1 inch 6 lines. Its closed base (ib., fig. 4) has a breadth of $7\frac{1}{2}$ lines; its presents a sub-bilobed form, concave transversely, convex from before backward. At the sides of the hæmal canal or rather slit, the arch has a fore-and-aft breadth of 4 lines; the

spine expands to twice that extent, with an obtusely rounded termination. In the twenty-seventh caudal vertebra the hæmal arch and spine are reduced to a length of 1 inch 2 lines; the spine progressively decreases to the thirty-second vertebra, beyond which the hæmal element ceases to be developed.

The centrum of the twenty-seventh caudal (Pl. 56, fig. 5, 27) is 1 inch 10 lines long; the anterior surface is 1 inch in depth, 1 inch 2 lines in breadth. The coalesced base of the neural arch has an extent of 1 inch; the prezygapophyses (*z*) are 9 lines in length; the neural spine (*ns*) is 1 inch in length above the zygapophysial surfaces, its summit penetrates the base of a superincumbent dermal bone, and the hæmal spine (*h*) has a similar relation to the dermal bone below. But both dermal bones may have been pressed nearer to the vertebra than in the living animal as the soft parts became dissolved away. The thirty-second caudal vertebra is 1 inch 4 lines in length, with a terminal breadth of 9 lines and a middle breadth of 6 lines. Its neural surface, showing the coalesced neural arch (*n*), from which the processes have been broken away, is figured in Pl. 56, fig. 6, the hæmal surface is represented at fig. 7, with the last hæmal arch (*h*), which is not quite closed above. The thirty-fourth caudal vertebra (ib., fig. 8), is 1 inch 2 lines in length; the breadth of its front articular end is 7 lines. The anchylosed neural arch has a basal extent of 9 lines; it is convex across the middle, like a saddle, rising into a short pyramidal process (*ns*) behind, like its peak; and still giving off the pair of long and slender prezygapophyses (*z*) from its fore part, which clasp the spine or peak of the antecedent vertebra.

The thirty-five caudal vertebræ, of which the principal distinctive characters have been above described, give a total length of 5 feet 8 inches 3 lines. The extent of dislocation between a few of these vertebræ would make a deduction of about 2 inches from the above extent; but the few vertebræ missing from the end of the tail, and reduced, as shown by parts preserved, to slender centrums, may, probably, have carried the length of the tail to about 6 feet.

The trunk-vertebræ include, as has been shown, four sacral, one lumbar, sixteen dorsal, and seven, or at least six, cervicals, and these vertebræ average each a length of 2 inches; the total length of the vertebral column of the trunk, estimated as including twenty-eight vertebræ, would be, on the above average, 4 feet 8 inches, or, allowing for intervertebral soft parts, 5 feet at the utmost in the recent animal.

The length of the head can scarcely have exceeded, more probably fell short of, 1 foot.

Thus we obtain an approximate estimate of the total length of the individual affording the before-detailed osteological characters of *Scelidosaurus* as not exceeding 12 feet from the snout to the end of the tail. But detached frag-

ments of the fossilized skeleton of other individuals from the lower Lias of Charmouth indicate a larger size, and that the present is not that of a mature Scelidosaur.

In the general osteological characters of the vertebral column we find this genus agreeing with *Hylæosaurus* and *Teleosaurus.*

None of the anterior vertebræ present the opisthocœlian modification characteristic of the Crocodilian genus *Streptospondylus* and in a minor degree of the Dinosaurian genera *Chondrosteosaurus*, *Cetiosaurus*, and *Megalosaurus;* in this respect they come nearer to the vertebral type of the *Iguanodon.*

Not any of the anterior dorsal vertebræ develops the spinous process of so disproportionate a length as they present in the carnivorous *Megalosaurus.* Although the neural arch becomes loftier than that of *Crocodilia* in the dorsal region of the spine, the exterior of the peduncles or neurapophysial laminæ does not present the complex configuration produced by the strong, oblique ridges underpropping the diapophysis in *Iguanodon* and *Chondrosteosaurus.* Certain vertebræ have a small unossified central part, relatively less than in *Polypthychodon;* none show the extent of permanent chondrosal tissue characteristic of *Chondrosteus.* Upon the whole, I find the closest agreement to be between *Scelido-* and *Hylæo-saurus* in the characters of the vertebral column; and I infer for both, but especially for *Scelidosaurus*, a greater aptitude for swimming than in the larger *Dinosauria.*

The scapular arch has been compressed transversely to a degree which has produced fracture of the right coracoid (Pl. 49, 52′), without material displacement in its relations to the left (Pl. 50, 52 and 52′), but with corresponding approximation of the two scapulæ (Pl. 49, 50, 51 and 51′), which have squeezed together, with some fracture and more dislocation, the interposed parietes of the thorax. The right scapula (Pl. 49, 51) is least displaced; it extends along the first seven dorsal vertebræ, overlapping the spines of the last two. It is long and rather narrow; thickest above the humeral articulation, narrowest at its middle part, becoming broader and thicker towards its free end or dorsum, the margin of which describes a moderate and regular convex curve. The length of the bone to the fore part of its coracoid end is 13 inches; its least breadth is 2 inches; that of the base is 4 inches 10 lines. The body of the scapula describes a slight convexity outward in its course to the humeral joint, the expanded portion in front of which is gently excavated for a triangular space 4 inches long; the apex being upward, with a well-defined boundary, indicative of the attachment of a muscle to this part. The anterior border is almost straight through three fourths of its extent from the base, then becomes slightly concave to the anteriorly produced angle of the coracoid end. The posterior border is more deeply concave, through the production of the thickened part of the bone to form the

humeral articulation (Pl. 50, *h*). So much as is exposed of this surface is slightly concave transversely, slightly undulating in the opposite direction, 2 inches in breadth. The articulation (*c*) with the coracoid (Pl. 49, 52′) is a straight harmonia. At the upper part of the humeral articular process there is an oblong notch, with slightly raised borders. The left scapula (Pl. 50, 51) has yielded in two places to the external pressure, but without separation of the broken parts. It gives the same indication of the triangular muscular surface on the outside of its distal end as does the right scapula, the apex being defined by a better preserved, slightly raised, obtuse border. The fore part of the acromial end of the scapula (*a*), though fractured like that on the right side, is here better preserved, and gives a breadth of nearly 6 inches to this end of the bone. The humeral articulation (*h*) measures 2 inches 6 lines, the coracoid one (*c*) 4 inches. A small, oval, dermal bone (*d*), 1 inch 6 lines by 1 inch 3 lines, overlies the fore part of the scapulo-coracoid harmonia. It is flattened, slightly convex externally, like some others that seem to have defended the skin of the under surface of the trunk.

The coracoid (ib., 52) is an almost circular, flattened, discoid bone, 5 inches in antero-posterior diameter and $4\frac{1}{2}$ inches in transverse diameter; the margin is most modified where it is expanded in two inches of its extent to contribute the coracoid portion (*h*) of the humeral joint. The scapular articular border (*s*) presents less thickness. The mesial or sternal border (*m*), continuing the circular curve, touches its fellow (52) by only a small part of its circumference. The average thickness of the coracoid plate is 7 lines. About 1 inch 3 lines from the scapular surface there is a foramen, 5 lines in diameter. The free border of the entire coracoid appears to be raised, but this may be due to the included surface having been crushed in and cracked by external pressure.

In the hinder interspace of the coracoids there is a flattened mass of a rhomboidal form, composed of scattered portions of thin, dark, osseous substance, cemented together by matrix, which is discoloured by carbonaceous material. No part shows the continuous roughened, but compact, structure of the dermal bones. It appears rather to be the remains of some partially ossified element of the endoskeleton. In its position it corresponds with the sternum. There is a fainter trace of the same kind of material, or discoloration of the matrix, at the anterior interspace of the coracoids.

The humerus, which is preserved on the left side (Pl. 50, 53), has been singularly crushed and flattened; the side of the middle of the shaft being broken away, exposes a small medullary cavity. The distal end (*d*) is broken off, and slightly overlapped by the shaft (53). The length of the humerus is 11 inches 3 lines. It presents a sigmoid flexure, the distal end slightly bent downward or forward; the proximal articulation, moderately convex, is 3 inches 8 lines in the long diameter;

the fore part is produced into a strong ridge, here partly broken away. The distal end is 5 inches across, and is moderately concave transversely behind. An osseous tubercle, 1 inch 4 four lines by 10 lines, is cemented to the anconal surface; a second similar bone is attached to the interspace between the inner condyle and the slightly dislocated ulna. These are more probably parts of the scattered dermo-skeleton than tendinal sesamoids of the extensor of the forearm.

The acromial end of the ulna (Pl. 50, 55) presents a convex border 2 inches 2 lines in breadth. The mutilated head of the radius (ib., 54), preserving its natural relations to the outer condyle of the humerus, is 1 inch 6 lines in length.

The shafts of the radius and ulna, with the rest of the bones of the fore limb, have been broken away.

Four oval, dermal bones, like those overlying the humerus and ulna, are attached to the matrix in front of the humerus and radius.

Behind the fractured sternal end of the right coracoid (Pl. 49, 52) is the dislocated head (53) and anterior expanded pectoral process (*p*) of the right humerus (ib.), showing a thickness of 7 lines where it has been broken off. The transverse diameter of the humerus at this part is 6 inches, with a thickness of the shaft not exceeding 2 inches 9 lines, showing that the humerus in *Scelidosaurus* was more expanded and compressed proximally than in any existing reptile, and in this respect resembling the same bone in the Dicynodonts.[1]

The proportions of the entire fore limb of *Scelidosaurus*, as indicated by the length of the humerus, would be those of the same limb in *Teleosaurus*. The humerus is shorter than the scapula, barely equalling the extent of four coarticulated middle dorsal vertebræ. There is no trace of clavicle in the present specimen; the functions of the fore limb seem, therefore, to be less important in regard to locomotion on land than in Iguanodon, Megalosaurus, and modern Lizards. Yet the shape and proportions of the coracoid, as I pointed out in regard to the *Stagonolepis* when the remains and impressions of that reptile were submitted to my inspection by Sir Roderic I. Murchison, at Leeds, during the meeting of the British Association, September 24th, 1858,[2] show the distinction from the Crocodilian order and the affinity to the Thecodontion order and to modern Lacertilia, or give evidence of a more generalised reptilian character, in these extinct reptiles with dermal bones and scutes of the Lower Liassic and Upper Triassic deposits.

1 Op. cit., vol. i, p. 31, vol. ii, pls. 30—36.

2 Art. "Palæontology," 'Encyclopædia Britannica,' vol. xvii, p. 130, in which, in reference to the Elgin matrix of *Stagonolepis*, it was stated that "no characteristic Devonian or Old Red fossils of any class have been discovered associated with the foregoing evidences of reptiles, which, according to the determination of strata by characteristic fossils, would belong to the secondary or mesozoic period."

Pelvic Arch and Limb. Pls. 53, 57, 58.

The left iliac bone (Pl. 53, figs. 1 and 2, 62) retains almost its natural relations with the sacrum. The right iliac bone (ib., 62) has been obliquely dislocated. It is a long bone, with a sigmoid flexure (ib., fig. 2, 62), convex upward and outward in its anterior two thirds, more slightly concave in the rest of its extent. Of the left ilium an extent of 18 inches is preserved, a part, apparently a small one, being wanting from both extremities. The narrowest portion of the bone is that which is produced anterior to the first sacral rib (ib., *s* 1); this portion is 6 inches in extent, triedral in form, 2 inches 6 lines in breadth where it joins the obtuse, expanded end of that rib. Beyond or behind the first sacral abutment the ilium progressively expands to a breadth of about 5 inches opposite the fourth abutment (*s* 4). The thickness of the bone, as exposed in the fracture of the left ilium, is from 2 inches to $2\frac{1}{2}$ inches. The middle third of the substance of the bone shows a rather open, cancellous structure; external to this the texture is much closer, with a compact, peripheral layer of from 1 to 2 lines in thickness. The articular cavity for the femur is on the under and outer side of that part of the ilium which is opposite its symphysis with the first two sacral vertebræ (*s* 1 and *s* 2).

The fore part of the right ilium (62′) has been thrust away from that junction, and the femur (65) is dislocated, passing beneath the ilium, with the head abutting against the sacrum. The summit of the great trochanter terminates rather more than an inch below the articular head of the bone. The breadth of the femur across this part of the trochanter is 3 inches 6 lines. The length of the femur (Pl. 57, fig. 1, 65) is 1 foot 4 inches. The inner process or ridge (*t*) begins to be developed about $5\frac{1}{2}$ inches from the head of the bone, and is 2 inches in extent. The shaft of the bone at this part is rather flattened, both anteriorly and posteriorly, and is most convex externally. It assumes a rounder circumference about 1 inch below the inner process, where the bone is 2 inches 4 lines in diameter. Thence it expands to the condyles (*a* and *b*), becoming flattened anteriorly and concave posteriorly. The condyles are but feebly indicated by a shallow notch on the fore part, but more distinctly behind, where they are produced backward. The hind extremity of the outer condyle (*b*) is marked off by a notch from the rest of its articular surface lying anterior and external to it. This posteriorly defined part articulates with the outer condyloid production of the head of the tibia, the fibula articulating with the rest of the outer condyle. The transversely convex fore part of the shaft of the femur is divided on each side by a low ridge from the flattened surfaces converging towards it, the one from the outer side, the other from the inner process (*t*). The exterior of these ridges is continued further down the bone

than the opposite one. This femur, being broken across about 6 inches from its upper end, shows a medullary cavity of about $1\frac{1}{2}$ inch in diameter, with a compact and finally cancellous wall, which is nearly an inch in thickness next the base of the inner process, and is about 3 lines in thickness on the opposite side of the shaft (Pl. 57, fig. 2). The transverse breadth of the shaft here is 2 inches 7 lines, the fore-and-aft breadth is 2 inches. The transverse breadth of the distal end is 4 inches 10 lines; the fore-and-aft breadth of the outer condyle is 3 inches 3 lines, that of the inner condyle 3 inches 8 lines; the depth of the posterior inter-condyloid notch is 1 inch 3 lines.

The proximal ends of the tibia and fibula are crushed below their articular surfaces; most so in the right leg, with fracture of both bones. The medullary cavity of the right tibia has been obliterated by this violence, and the strong, compact wall broken and crushed in upon it. The fibula, with a smaller cavity and thicker, compact walls, has better resisted the pressure, especially in the left limb.

The length of the tibia (Pl. 57, 66) is 12 inches 10 lines, that of the fibula (ib. 67) is about an inch shorter. The expanded upper end of the tibia passes over the outer and part of the front surface of the head of the fibula;[1] the expanded lower end of the tibia passes, in part, behind that of the fibula, showing a kind of twisted, terminally, overlapping relation between the two bones. There is a distinct interosseous space (*o*) between the upper three fourths of their shafts. The breadth of the proximal end of the tibia, which may be a little increased by compression, is 5 inches 6 lines. The breadth of the distal end is 4 inches 6 lines. The tibia, which, on the left side, has suffered least compression at its upper end, and has been partially dislocated from the femur, shows a coadapted surface of very similar shape to that of the femur, convex from before backward, slightly concave transversely at the back part of the joint. In both bones the articular surfaces are rough, as if they had been connected together ligamentously. The tibial articular surface divides posteriorly, as before noted, into two condyloid processes, with an inter-condyloid space of about 2 inches breadth: one condyle is for the inner condyle of the femur, the other is adapted to the posterior prominence of the outer femoral condyle. The back part of the proximal end of the fibula next the outer condyle of the tibia is similarly produced into a convex protuberance. The fore and outer part of the tibia is produced into a strong procnemial tuberosity or process.

The shaft of the fibula contracts to a diameter of 1 inch 10 lines, and then expands transversely, but without corresponding fore-and-aft enlargement, to the distal breadth above recorded.

[1] In their natural relative positions, the fibula has been slightly dislocated outward in the left leg. (Pl. 57.)

To the major part of the distal end of the tibia, at least to two thirds of its inner or tibial side, is articulated the tarsal bone (*a*), including the coalesced homologues of the astragalus, naviculare, with the ento- and meso-cuneiform bones, of the mammalian tarsus. This bone (Pl. 57, fig. 1, *a*) presents an anterior surface of an elongated, irregular, triangular form, with the apex tibiad or toward the inner side of the tarsus. It becomes narrower as it proceeds backward beneath the tibia (ib., fig. 3, *a*), its articular surface with which is concave from before backward, favouring flexion and extension, or motion of the foot to and fro. Its distal surface is convex in the same direction, and is sinuous transversely.

The calcaneum (ib., figs. 1 and 3, *l*) articulates with the distal end of the fibula (fig. 1, 67) and with the outer third of the same surface of the tibia (fig. 3, *l*).

The next most intelligible tarsal bone is that (figs. 1 and 3, *b*) which articulates with the calcaneum (*l*) and with the two outer metatarsals (*iv* and *v*). Its largest surface is turned forward or upward; its posterior surface is a smaller convex protuberance; this bone answers to the cuboïdes.

At the back part of the tarsus there projects the base of a wedge-shaped bone, (fig. 3, *e*) seemingly partially dislocated backward, which mainly supports the middle metatarsal (*iii*), and extends partly over the fourth (fig. 3, *iv*). The apex of this bone appears on the front side of the tarsus (fig. 1, *e*) in the interspace between the astragalus (*a*), cuboïdes (*b*), the third and the fourth metatarsals. I regard this bone, therefore, as answering to the ecto-cuneiform; I cannot discern any trace of other cuneiform bones, the fibro-cartilage by which the interspace between the bone (*a*), and the first and second metatarsals, was most probably occupied held partly the place of the meso- and ento-cuneiform bones. From this it appears that the tarsus of *Scelidosaurus* includes but four bones, as in the Crocodile (Pl. 58, fig. 4.) In the Lizard (*Varanus*), fig. 3, an ossification in the fibro-cartilage at the base of the second metatarsal establishes the "meso-cuneiforme," and leaves the "ento-cuneiforme" to combine with the naviculare and astragalus in the bone (*a*).

The metatarsus of *Scelidosaurus* consists of five bones. Of these, the fifth (Pl. 56, figs. 1 and 3, *v*) is abortive, and adherent to a rough ridge on the outer part of the base of the fourth metatarsal, with its proximal half extending over the interspace between that bone and the cuboid to articulate with the latter. It was not, however, flattened and expanded, as in the Crocodile (Pl. 58, fig. 4, *v*), but was slender and styliform, if we may judge by the proximal end which fortunately remains attached in the left hind foot of *Scelidosaurus* (Pl. 57, fig 1, *v*). It most probably did not support a toe, or make any distinct appearance in the entire foot. The other four metatarsals support each a fully-developed toe, with the progressive increase in the number of phalanges characteristic of saurian *Reptilia;* the first having 2, the second 3, the third 4, and the fourth 5 phalanges.

The metatarsal of the first or innermost toe (Pls. 57 and 58, *i*), is 2 inches 9 lines long. With its proximal end laterally compressed, and abutting against the corresponding end of the second metatarsal, which is much expanded in that direction. The distal end of the first is 13 lines in breadth, with a convex articular surface. The first phalanx of the toe (*i*) is 2 inches long, 14 lines across the base, convex transversely towards the dorsum of the foot, flattened transversely and slightly concave lengthwise, towards the sole. The ungual phalanx is $1\frac{1}{2}$ inch in length, and 1 inch in basal breadth; is sub-depressed, and curved downward. About 3 lines in advance of the joint, its breadth is increased by two lateral ridges. The apex is subacute. The under surface is marked by many fine, wavy ridges. There are two obtuse longitudinal prominences on the under surface near the joint, for the advantageous insertion of the flexor tendons, and there is a rough prominence at the middle of the dorsal surface, near the joint, for the insertion of the extensor tendon. The dorsal surface near the margins and apex, is sculptured by vascular grooves. The total length of the first digit (*i*) is 6 inches.

The second metatarsal (ib., *ii*) is 5 inches in length; with a proximal articular surface 1 inch 6 lines in breadth, sinuous but almost flat: this surface presents almost double the transverse extent in the antero-posterior direction. The inner and anterior part of this surface is produced inward, or tibiad, apparently to afford an abutment or attachment, at least in part, to the proximal end of the first metatarsal. The outer or fibular side of the second metatarsal is almost straight, the inner or tibial one concave, the expansion at both ends taking place chiefly in that direction. The distal articular surface is convex from before backwards, with a median groove producing a transverse concavity between the two convexities or condyles, at the posterior half; and these slightly project backward. The first phalanx of the second toe is 1 inch 3 lines in length, 1 inch 7 lines across the proximal, and 1 inch 6 lines across the distal end; the diameter from before backward at the middle of the shaft is 6 lines, the phalanx is consequently broad and sub-depressed. The posterior or plantal surface at the proximal end is slightly produced. The distal articular convexity extends a little way upon the middle of the dorsal surface, and slightly swells out into two condyles at the opposite surface. The second phalanx is much shorter in proportion to its breadth, which at the base is 1 inch 6 lines; the length being 1 inch 7 lines; the tibial border is short and concave; the fibular one is straighter and one third longer. The ungual phalanx (*ii*) differs chiefly from that of the first digit in its superior size, being 2 inches in length and 1 inch 4 lines in its greatest breadth; the fibular margin is convex, the tibial one slightly concave. A side view of the bone, of the natural size, is given at fig. 4, Pl. 57.

The length of the third metatarsal (ib., *iii*) is 5 inches 4 lines. It is more symmetrical in shape than the rest. The transverse breadth of the proximal end is

1 inch 8 lines; the fore-and-aft breadth is 2 inches 1 line. The thickness in this direction diminishes rapidly towards the distal end; the transverse dimension decreases in a much less degree; this, at the middle of the bone, being 1 inch 2 lines, whence it increases to a distal transverse breadth of 1 inch 11 lines. The configuration of this articular surface resembles that of the second metatarsal; the fore-and-aft breadth of the condyle is 1 inch 6 lines. The proximal phalanx of the third toe (ib., *iii*, 1) is 1 inch 2 lines in length, 1 inch 10 lines across the base, and 1 inch 3 lines across from before backwards. On the middle of the outer border is a tuberosity; each side of the distal end is deeply impressed; the distal articulation resembles that in the second toe. The greatest transverse breadth of this phalanx is 1 inch 7 lines. The second phalanx (ib., 2), with a basal breadth of 1 inch 6 lines, is only 1 inch 7 lines in length. The distal articulation is 1 inch 5 lines in breadth. The third phalanx (ib., 3), with a basal breadth of 1 inch 3 lines, is 1 inch 2 lines in length, with a distal breadth 1 inch 1 line. The ungual phalanx (ib. 4) is more depressed in proportion to its breadth than that of the preceding toe; in other respects it resembles it in shape.

The fourth metatarsal (ib., *iv*), is 4 inches 5 lines in length, of an unsymmetrical figure, receding from the middle metatarsal along its distal half, which is concave lengthwise on the tibial side; the fibular side presents a general but slighter concavity; this metatarsal is triedral, the fore and back surfaces converging to an obtuse, narrow, outer border, significant of its terminating that side of the foot beyond the representative style of the fifth digit (*v*). The fourth metatarsal measures 1 inch 9 lines across the base and 1 inch 7 lines from before backwards, at the tibial side of the base; the fibular side being reduced to the narrow rough ridge for the ligamentous attachment of the fifth abortive metatarsal. The breadth of the shaft of the fourth metatarsal at its lower third is 1 inch 1 line; that of the distal articular surface is 1 inch 5 lines. The first phalanx of the fourth toe is 1 inch 11 lines in length; the basal breadth is 1 inch 8 lines and the distal breadth is 1 inch 5 lines. The tibial angle of the proximal surface is most produced. The fore-and-aft dimensions of the shaft do not exceed 6 lines. The second phalanx is 1 inch 2 lines in length, and 1 inch 3 lines in basal breadth. The third phalanx is 1 inch in length, 1 inch 4 lines in breadth; the fourth phalanx is 9 lines in length, 1 inch 2 lines in breadth. The ungual phalanx is 1 inch 6 lines in length; 8 lines across its articular surface, 11 lines across its broadest part, caused by the aliform expansions of the bone beyond the articulation. It curves downwards and inwards, or towards the tibial side, to a subacute apex; the characters of its surface correspond with those of the larger ungual phalanges of the preceding toes.

From the abortion of the fifth digit, and the disproportionate shortness of the first, we have in *Scelidosaurus* the example of a reptile manifesting a tendency to the tridactyle type of the hind foot, and this is effected in its remote successor of

the Wealden period—the *Iguanodon*—by the suppression of the first, and by a similar atrophy of the fifth digit. The foot-prints of *Scelidosaurus* would terminate forward by the marks of four claws, the innermost falling short of the base of the second, this and the fourth reaching the same line, and the intermediate third claw extending farthest. The hind foot-prints of *Iguanodon* are tridactyle.[1]

The total length of the foot of *Scelidosaurus* is 1 foot 1 inch 6 lines; the length of the leg ("cnemion") is 1 foot; the length of the thigh is 1 foot 4 inches; consequently the total length of the hind limb is 3 feet 5 inches; and, allowing for the fibro-cartilaginous matter of the joints and the terminal claws, the limb may have been 3 feet 8 inches long in the recent animal.

The femur equals the length of about seven co-articulated dorsal vertebræ, and, with the leg, manifests longer proportions to the body than in the *Crocodilia*; but the foot presents shorter and broader proportions, although it has the same number of toes. *Scelidosaurus*, however, differs from *Teleosaurus* and modern *Crocodilia*, in retaining the ungual phalanx of the fourth toe, as in modern lizards (Pl. 58, fig. 3, *iv*); although it differs from these and resembles the Crocodiles in the non-development of the fifth toe. The interesting evidence of this intermediate relationship afforded by the bones of the hind foot, as by some other parts of the skeleton, is illustrated by the outline figures of the skeleton of the hind foot (Pl. 58) in *Varanus*, fig. 3, in *Crocodilus*, fig. 4, and as similarly restored in *Scelidosaurus*, fig. 2.

In the same plate is figured, of half the natural size, the bones of the right hind foot of the skeleton of the Scelidosaur which has yielded the subjects of the present Monograph; showing the effects of pressure in fracturing and partially dislocating the metatarsal segment, after all the joints of the toes had been cemented by the surrounding hardened matrix in their respective varied numbers and co-adjustment in each toe.

Dermo-skeleton.

The bones belonging to this system were extensively developed in *Scelidosaurus*, and are for the most part of a massive character. They have been much displaced in the present specimen, partly during the decomposition of the carcass, and partly by subsequent pressure due to movements of the imbedding stratum; but retain their most intelligible natural relations to the endo-skeleton in the caudal region: in which part, therefore, I shall begin their description, as they were found, on exposing the vertebral characters on the left side, from the end of the tail forwards; and were either removed, or left *in situ*, as the case required.

[1] *Ante*, Vol. i, p. 374, Pls. 43, 44 (*Dinosauria*).

At the thirty-first caudal vertebra, for example, there was attached to the back part of the neural arch, and pressed rather obliquely to the left side, an elongated triedral dermal bone, with the narrowest side or surface forming the base, and the two broader or larger lateral surfaces converging at an acute angle to an upper ridge. Much of this ridge on the fore part of the bone had been broken away in the original exposure of the specimen; the length of what remained was 1 inch 2 lines, with a basal breadth of 6 lines. The sides of the bone seemed as if worm-eaten, by narrow curved grooves with intervening small, oblong, and circular pittings. The texture as exposed by the fracture was compact, reflecting a lustre. Between the twenty-ninth and thirtieth vertebræ there was the basal part of a similarly shaped dermal bone, 1 inch 9 lines in extent, with a basal breadth of 9 lines. It lies upon the right side of the co-adapted halves of the neural arches of these vertebræ, but may have been displaced from the median line, and this is more probable as the base of a dermal bone crossing the articulation between the centrums of the same caudal vertebræ has also been pressed towards the right side, on which the carcass of the reptile appears to have rested in the matrix. But any doubt as to the relations of the dermal bone above indicated was dissipated by the better preservation of those found in connection with the twenty-seventh and twenty-eighth caudal vertebræ (Pl. 56, fig. 2), and which are represented of the natural size in figure 5 of the same plate.

The dermo-neural bone (*d n*), was found fractured, with a slight displacement of the back part of its base: when entire, it had a longitudinal extent of 3 inches 6 lines, and a vertical one of 2 inches. The base is hollow, and has been crushed by the lateral pressure; but seems to have had a breadth of nearly an inch. The sides converge to the upper margin, which describes a bold convex curve from before backwards, along two thirds of the contour, and then descends in a straighter line obliquely backward to the hinder angle of the base. This dermal bone extends from above the prezygapophyses (*z*) of the twenty-seventh caudal vertebra to the fore part of the spine of the twenty-eighth. On removing part of the side of the base of the dermo-neural bone the spine (*n s*) of the twenty-seventh vertebra was seen to have penetrated the basal cavity, as far as that extended into the substance of the dermal bone; but I incline to think that fibrinous or other soluble tissue intervened in the living reptile, and that the position of some of the more anterior dermo-neurals, situated at a higher level above the neural spines, was the more natural one.

The dermo-hæmal bone (ib., *d h*) presents a longitudinal extent of 2 inches 3 lines, with a vertical one of 13 lines, and a basal breadth of about 9 lines. The hæmal spine of the twenty-seventh vertebra (*h*) seems also to have entered a hollow in its base, where it was exposed by removal of part of the left wall of the basal cavity. But this had been pressed up to the under part of the

centrums, almost touching the posterior half of the twenty-seventh and the contiguous two thirds of the twenty-eighth caudal vertebra; obliterating an interspace which should have been occupied by muscle, tendon, ligament, and other soft parts in the recent animal.

The dermo-hæmal spine below the twenty-fifth and twenty-sixth caudals differed only in its larger size from the succeeding one. Part of the base of the corresponding dermo-neural was preserved.

In the series of nine consecutive caudal vertebræ (Pl. 56, fig. 1), the number and disposition of the dermo-neural and dermo-hæmal bones were more fully and satisfactorily exhibited. Three consecutive dermo-neurals extended over a series of seven vertebræ, from near the fore part of the first to near the hinder half of the last of these seven, each extending over the interspaces of two vertebræ. The corresponding dermo-hæmals are of smaller size, cross only one intervertebral space, which is the second or posterior of those so crossed above, and their hinder end is a little further back than that end of their homotype above. But, in working out these vertebræ, indications of a third series of caudal dermal bones were first met with. There extended over the articulation between the twenty-first and twenty-second caudals the base of a dermal bone, 3 inches long, crushed, with its apical ridge broken off. On its removal, the vertebræ it crossed were seen to have been displaced to the extent of nearly an inch. The position of this bone, and the ascertained relations of the neural and hæmal dermal bones to their vertebræ, made it improbable that it was one of either of these series displaced; and attention was quickened, which led to the detection of a similar appearance further in advance, to be presently described.

The best preserved dermo-neural, in the series of nine caudal vertebræ (Pl. 56, fig. 1, *d n*), presents a basal longitudinal extent of 3 inches 5 lines, with a basal breadth of 1 inch 9 lines; its *quasi* worm-eaten, rugose sides, converge to an upper margin, not quite entire, but with apparently a contour resembling the dermo-neural in fig. 5. The present larger bone overlies the twentieth and contiguous portions of the nineteenth and twenty-first caudal vertebræ. The corresponding dermo-hæmal bone (*d, h*), with a longitudinal basal extent of 2 inches 6 lines, and a basal breadth of 1 inch 3 lines, underlies the twentieth and twenty-first caudals, extending along a greater proportion of the former. Its sides, similarly but more finely sculptured than the dermo-neural above, converge to a convex inferior border; the depth of the side being not less than 1 inch 6 lines. The next dermo-neural in advance overlies the eighteenth and contiguous half of the seventeenth caudal vertebræ. It presents a basal extent of 3 inches 6 lines, with a basal breadth of 1 inch 6 lines. The base of the corresponding dermo-hæmal spine is preserved, which underlaps the hinder two thirds of the eighteenth and the front third of the nineteenth caudal. Its base is

2 inches 7 lines in length, with a moderate contour. The apical ridge and left side of this bone have been broken away.

Between the above-described dermo-neural and dermo-hæmal bones there was the base of a lateral dermal bone, 3 inches 5 lines in length, applied over the eighteenth and part of the nineteenth caudal vertebræ, like that between the twenty-first and twenty-second. The portion preserved in exposing these vertebræ is figured in the interspace produced by their slight dislocation, into which it had been wedged by pressure. I conceive it to have been the direct instrument of the dislocation, receiving and transmitting the extraneous pressure; and at a period when the vertebræ in front and behind were sufficiently free in their bed to allow of being pressed close together, with obliteration of their natural interspaces originally occupied by the soft inter-articular material; the extent of such interspace is probably shown between the twenty-second and twenty-third caudals (Pl. 56, fig. 1). From the evidence of the dermo-neurals and dermo-hæmals, *in situ*, in the present series of vertebræ, the dermal bone above described could not be one of these series displaced; and I infer from it, and the evidence of a similarly situated bone in a remoter part of the tail, that this appendage was defended by a series of lateral as well of upper and lower dermal ossicles, though, perhaps, in less number, and of a flatter figure, along the sides.

The next dermo-neural in advance overlaps the sixteenth and the contiguous half of the fifteenth caudal vertebræ; but its hinder end, as well as a part of its summit, are broken away. What remains, measures 3 inches 4 lines in length with a basal breadth of at least two inches. The margin of the base of all the above-described dermo-neurals describes a gentle convexity.

As the dermo-neurals advance in position, they progressively acquire increase of basal breadth, to near the base of the tail, retaining the average length of $3\frac{1}{2}$ inches, with a small increase of height. Three dermo-neurals range along an extent of the five vertebræ (eleventh to fifteenth caudals) figured in Pl. 55, fig. 3; and the same relative number and position are shown in the five antecedent caudals (ib., fig. 1, *dn*).

On the right or imbedded side of the vertebræ, overlying the centrum of the fourteenth, and contiguous parts of the thirteenth and fifteenth vertebræ, is the base of a dermo-lateral bone, 3 inches 3 lines in length, 2 inches 2 lines in breadth, the sides converging at an open angle, but with their terminal ridge broken off. This representative of the lateral series of dermal bones would seem to show that they had greater breadth and thickness than either those of the upper (neural) or lower (hæmal) dermal series. The right side, where these additional indications of a lateral series of dermal bones are preserved, was that which was left imbedded in the matrix; the left side being that which was exposed by the original quarrying operations. It is probable, therefore, that the dermo-lateral bones of the left

side, with the exception of the few remains above noticed, were in the matrix so detached. The characters of the caudal vertebræ figured in Pls. 55 and 56 were displayed by careful removal of the matrix left adhering to the parts originally exposed; during which operation the portions of the dermo-lateral bones which had been pressed inward, and contributed to the dislocation of the twenty-first from the twenty-second, and of the eighteenth from the nineteenth caudal vertebræ, were brought to light.

A dermo-neural bone overlies the ninth and tenth caudals (Pl. 55, fig. 1); another over the seventh and eighth (*d n*); a third over the sixth and fifth. The fracture through the middle of this latter bone (Pl. 54, fig. 3), shows the form and depth of the angular excavation at its base, which rested, probably with interposed ligamentous substance, upon the summit of the neural spine of the caudal. The corresponding dermo-hæmal bones, displaced so as obliquely to overlap the hæmal spines on the right side, are also preserved; and on this side there are as many dermo-lateral scutes, but more fragmentary and dislocated.

In the block of lias with the first caudal vertebræ (Pl. 54, figs. 1 and 2), is the anterior half of the dermo-neural overlapping the fifth and sixth of that series. Two similar bones with a basal excavation exposed by fracture in one of them, are situated to the right side of the fourth and third caudals, which may be dermo-laterals or displaced dermo-neurals. A portion of a massive dermal bone lies upon a part of the ilium contained in this slab. The rest of the armour of this part of the base of the tail has been removed. The like is the case with regard to the upper part of the block including the sacrum (Pl. 55). At its under part, in which are imbedded dislocated bones of the hind limbs, there are a few scattered portions of wedge-shaped dermal bones, similar in size to those at the base of the tail, but less pyramidal, and with more obtuse summits. A few smaller, flatter, subcircular dermal bones were met with in the course of exposing the parts of the endo-skeleton. One of these (ib., *d*), lies above the interspace between the left ilium and the third sacral rib (Pl. 55, fig. 1, *d*).

In the block of lias containing the fore part of the thorax and scapular arch a longitudinal series of eight dermal bones were found on the right side, overlapping the ribs, external to the diapophyses. These dermal bones were shorter and thicker than the caudal dermo-neurals, and had been subject to more or less fracture and some displacement. The best preserved was wedge-shaped, with the sides of the excavated base slightly convex, 2 inches in length, 8 inches 9 lines in breadth, the sides converging at a more open angle, but unequally, to a margin which shows a convex ridge. The inferior size and unsymmetrical shape of this bone seem to show that it formed part of a lateral row, which had been situated near a middle one, or had ranged along near the medial line of the back. The margins of these bones were not entire. The summit of a dermo-neural spine remains wedged

between the spines of the second and third dorsals, and another between those of the fourth and fifth dorsals (Pl. 49, *dn, dn*). On the left side of the thorax (Pl. 50) are preserved some of the upper lateral series of dermal bones (*d n l*), showing their natural position and intervals. On the same side, beneath the foregoing (Pl. 50, *d l*), are some larger wedge-shaped dermal bones. Three of these may have been displaced from above the neural spines. They are elliptical, 3 inches long, 2 inches broad at the base, with the sides converging with a slight concavity to the upper ridge, which has been broken off in each, so that its height is conjectural. Other evidences of dermal bones on the under part of this slab are too fragmentary and scattered to throw any light upon their natural arrangement. On the right side (Pl. 49), overlying the ends of the ribs, about ten inches distant from the vertebræ, are preserved three of a series of flattened, sub-ovate, dermal scutes (*da, da*), about 3 inches by 2 inches in the long and cross diameters, and from 2 to 4 lines in thickness. The outer surface exhibits the same character of sculpturing as do the dermal bones of the tail; the inner surface is smooth.

In the block containing the second and third cervical vertebræ the pair of lateral, unsymmetrical, dermal bones have been preserved nearly in their natural position. They are three-sided; the shortest is directed mesiad; the side next in length looks downward; the outer surface, more convex, is directed upward and outward, and is the most extensive. These scutes have been fractured through their centre. They show an external, very compact, layer of bone thickest on the outer or peripheral side. The rest of the bone shows a rather close cancellous structure. Above these, but slightly displaced, is a pair of wedge-shaped bones, which are probably dermo-neurals, indicative of a parial arrangement of these along the nape, contrasting with their single series above the tail. Each of these dermal bones are somewhat unsymmetrical in form, 2 inches 9 lines in the length of the base, 1 inch 9 lines in breadth, with the median surface more extensive than the outer, and both converging to a ridged summit, but which is broken away.

The anterior pair of nuchal scutes is preserved in connection with the occiput, overlapping the atlas (Pl. 48, fig. 1, *dn, r*). They are similar in shape, but smaller in dimensions, than those last described, and have been broken across.

From the sum of the foregoing observations, it may be inferred that the surface of the Scelidosaur was defended by several longitudinal series of massive dermal bones, those occupying the median and upper surface being arranged in pairs upon the nape and singly along the tail. External to these were a lateral series at least two in number, but probably more, on each side the trunk, having the same wedged and ridged shape as the dermo-neurals. Beneath these were flattened, ovate scutes along the lower lateral part of the thoracic-abdominal region. In the tail we have more decisive evidence of a single median row of large, symmetrical,

cuneiform, hollow-based, superiorly ridged dermo-neurals, with dimensions making three occupy the space of five vertebræ along the base of the tail, and nearly seven vertebræ along the hinder half of the tail. There was a corresponding median series of smaller and less vertically extended dermo-hæmal bones, and also a single series of dermo-laterals, of more depressed and fuller ovate form, on each side.

The accidents attending the decomposition of the carcass of this reptile seem to have had the chief share in the removal and displacement of so large a proportion of its coat of mail. Subsequent cosmical violence has been concerned in the fracture, the crushing, and in a certain amount of displacement of the constituent parts of the skeleton. Lastly, further fracture of the fossil bones has been due to the quarrying operations, by which the specimen was brought to light.

A few remains, including a femur, 5 inches in length, but with both extremities seemingly incompletely ossified, indicated a young *Dinosaur;* and with characters, as of the inner trochanter, in regard to shape and relative position, which led me to surmise that it might be part of an immature and very young individual of a *Scelidosaurus.* These remains were from the same liassic locality as the larger, probably adult bones.

To whatever extent the Saurian organization has been modified for terrestrial life, that has been, in no instance, such as to suggest an inability to swim. On the contrary, the disproportionate shortness of the fore limbs, even in *Iguanodon*, leads to the suspicion that they might be short in reference to diminishing the obstacles to propelling the body through water by actions of the strong and vertically extended tail; and that, as in the living land lizard (*Amblyrhynchus*), of the Gallopagos Islands, the fore limbs might be applied close to the trunk in the Iguanodon, when it occasionally sought the water of the neighbouring estuary or sea. One would suppose that the newly born or newly hatched young of a Dinosaur might be safer on shore than at sea, or at least in waters which, like those of the Liassic ocean, seem to have swarmed with carnivorous Enaliosaurus. If the Dinosauria were ovo-viviparous, and produced but few young at a birth, the remains from the lower Lias, noticed at p. 90, might be those of a fœtus borne by a gravid Scelidosaur to sea during an occasional excursion, and which by some casualty had there perished, and become imbedded, with her progeny, in the muddy bottom of the old Liassic ocean. I have not, however, been able to obtain precise evidence of the proximity of the small femur with the larger one of the *Scelidosaurus*, and bones of more than one small individual might have been expected to occur in juxtaposition if they had perished before birth. The analogy of the crocodile, moreover, would lead us to expect that the newly excluded or newly born Scelidosaur would be of smaller size than the individual indicated by the bones first discovered.

The general condition of the almost entire skeleton of a Scelidosaur organized, as seems by the structure and proportions of the hind foot, for terrestrial rather than aquatic life, or at least for amphibious habits on the margins of a river rather than for pursuit of food in the open sea, led me to infer that the carcass of the dead animal had been drifted down a river, disemboguing in the Liassic ocean, on the muddy bottom of which it would settle down when the skin had been so far decomposed as to permit the escape of the gases engendered by putrefaction. In that predicament the carcass would attract large carnivorous marine fishes and reptiles, and portions of the skin, with prominent parts not too strongly attached to the trunk, would probably be torn away before the weight of the bones had completely buried the carcass in the mud. In this way, perhaps, we may account for the loss of much of the dermo-skeleton and of the two fore feet. The larger hind limbs with their stronger muscles and ligaments, would offer better resistance to such predatory attacks; and they, at any rate, have been preserved. The agitation to which the body must have been subject in its course down the stream, and before it finally sunk and settled out of sight, would be attended, after a certain amount of decomposition of the flesh, ligaments, and other soft parts, with such an amount of dislocation as the ribs and other parts of the vertebral column exhibit along the otherwise well-preserved and completely consecutive series of the bony segments, from the skull to near the end of the tail. But the oblique compression of the skull, the flattening of the thorax, squeezed between the approximated piers of the scapular arch, attended with fracture of one of the coracoids, and other indications in the rest of the trunk, plainly bespeak the enormous pressure to which the fossil has been subject after its imbedding, and which must have been attended with still more injury and destructive obliteration of anatomical characters had it not been for the surrounding uniform support afforded by the matrix, compactly hardened around the petrified skeleton before those cosmical movements commenced to which the change in the position of the old Liassic sea-bottom has been due.

SUPPLEMENT No. II.

MESOZOIC LIZARDS.

Genus—ECHINODON,[1] *Owen.*

ECHINODON BECCLESII, *Owen.* '*Lacertilia*,' Pl. 11, figs. 1—9.

The specimens figured in the above-cited plate were discovered by S. H. Beccles, Esq., F.R.S., in the thin, fresh-water stratum at Durdleston Bay, Isle of Purbeck. They consist of portions of the upper and lower jaws of a Saurian, allied, by the shape of the teeth, to *Macellodon* (Pl. 11, fig. 10, *a—c*),[2] but of larger size, and with the thecodont implantation of the teeth. The crown belongs, in general shape, to that type, of which the teeth of *Palæosaurus*, *Scelidosaurus*, *Cardiodon*, *Hylæosaurus*, and even those of *Iguanodon*, are modifications. The teeth of the present genus are distinguished by the marginal serrations of the apical half of the crown, which increase in size from the apex to the base of that angular part of the tooth, the two basal points resembling spines, and terminating respectively, or forming the confluence of, the two thickened ridges (ib., *r*, fig. 2, *c*) bounding the fore and hind borders of the basal half of the crown.

The crown is supported on a subcylindrical fang, and suddenly expands, both transversely (Pl. 2, fig. 11, *c*) and antero-posteriorly (ib., *b*). In the former direction it as quickly begins to contract, and the outer and inner sides converge in almost a straight line to the apex; in the latter direction the crown continues expanding for about half, or rather more, of its longitudinal extent, with a slightly convex contour; it then rapidly contracts to the apex, the converging borders meeting at a right or somewhat acute angle, and being serrated as above described. The thickest mid-part of the crown forms a longitudinal rising, usually more marked on one side of the tooth; at the apical half the crown gradually becomes thinner towards the fore and hind margins; but at the basal half these margins are thickened, and cause the surface between them and the mid-rising to be undulated transversely. At the apical part of the tooth both the outer and inner sides are gently convex, the transverse section giving the thin-pointed ellipse, as in fig. 6, *b*.

The outer and inner enamelled sides of the crown each describe a curve at their base (fig. 3, *b*, *r*), convex towards the fang; these bases are somewhat thickened

[1] Ἐχῖνος, *hedgehog*, and ὀδοὺς, *tooth*, "prickly tooth."

[2] 'Quarterly Journal of the Geological Society,' No. 40 (1854), p. 422.

and rounded, so as to project from the fang; they converge at the fore and hind parts of the tooth, and unite at an acute angle (fig. 2, *c, r*), to form the long, basal points (fig. 3, *b, s*) of the serrated half of the crown. The foregoing characters apply to the majority of the teeth of *Echinodon.*

A portion of the left maxillary bone, with its outer surface exposed, is represented in Pl. 11, fig. 1, and in outline, of the natural size, at *a.* The anterior, probably premaxillary, part has been detached and broken. Three teeth, more or less fractured, project from sockets in the alveolar border of this part; their crowns are less expanded than in the typical maxillary and mandibular teeth. Part of the boundary of an external nostril is indicated at *n*, the larger maxillary fragment the first two teeth present a similar form, and the entire crown of the second shows it to be longer, as well as more slender, than the posterior teeth; it resembles a canine tooth in both shape and position, the crown being subcompressed and slightly recurved, as well as sharp-pointed. It would serve well to pierce and retain a living prey. It recalls a dental character of *Iguanodon.*

The tooth succeeding the laniariform one presents the typical characters; In fig. 1 are shown the impressions of four of the teeth preserved in the slab (fig. 2). Above the first impression (*o*, fig. 1) is the crown of a successional tooth, about to displace the tooth (*o*, in fig. 2). The outer side of maxillary teeth is shown, magnified, at *b, b.*

The remainder of the upper maxillary, with part of the palatine and pterygoid bones of the left side, are represented, magnified, in fig. 2, and of the natural size, in outline, at *a.* The extent of the inner alveolar wall, effecting, with the cross partitions, the lodgment of the teeth in sockets, is here demonstrated. The expanded crowns of the teeth come into contact. The inner surface of the crown is shown at *b*, in which the middle longitudinal rising is rather less prominent than on the opposite surface. The fore part of the crown is represented at *c.* The outer side of a portion of the right maxillary, with eight contiguous molars, is represented in fig. 3, and of the natural size, in outline, at *a.* There is a linear row of small foramina above the alveolar border. The median longitudinal rising of the crown of the teeth is more strongly marked on this, the outer surface. In fig. 4 is represented the inner surface of the posterior part of a right maxillary, containing six contiguous teeth, with a less prominent or less defined median rising of the teeth in this fragment; the last three teeth gradually decrease in size.

The inner surface of a portion of a mandibular ramus, with eight contiguous teeth, is represented at fig. 5, and in outline, of the natural size, at *a.* The fore part of a right ramus, consisting chiefly of the dentary element, is represented in figs. 6—8, and of the natural size, in outline, at *a.* Fig. 6 gives the outer side, but the whole vertical extent of the bone is only preserved at the symphysial end. The apex of a young tooth projects from the fifth of the sockets here preserved;

it is represented magnified at *a* and *b*. There is a linear series of small nervo-vascular foramina a little below the alveolar border. The crowns of the developed teeth have been broken away; their fangs in the sockets are shown in fig. 7; the anterior teeth are narrower than the rest, as in the upper jaw. On the inner side of the specimen (fig. 8), a considerable extent of the symphysis (*s, s*) is shown.

The posterior part of a broken dentary element of the left ramus is represented in fig. 9, showing the last eight teeth, and the impressions of the crowns of as many in advance. A portion of the crown, displaced, of the fourth from the last is preserved, and likewise portions also of those in advance, which have been broken in splitting the slab, so that they appear smaller than they actually were. The last three teeth are entire, and show a gradual decrease of size, as in the portion of upper jaw (fig. 4). A magnified view of the inner surface of the last lower tooth is given at *a*, fig. 9.

The reference of *Echinodon* to the Lacertians is suggested by its diminutive size and by certain characters of jaws and teeth, but the structure of the vertebræ and limb-bones must be ascertained before the ordinal affinities of *Echinodon* can be satisfactorily determined. The modifications of the mode of implantation of the teeth in the known limits of the Dinosaurian order affect the value of the thecodont character as a mark of affinity.

THE

FOSSIL REPTILIA OF THE LIASSIC FORMATIONS.

CHAPTER IV. ORDER—CROCODILIA.

Of the fossil evidences of this order of Reptiles, represented by the existing genera *Crocodilus*, *Alligator*, and *Gavialis*, those referable to such genera have not hitherto come to my knowledge from strata older than the tertiary formations (vol. i, pp. 80—129).

Vertebræ and other remains from Cretaceous series, as the Green-sand of Sussex, show vertebral modifications of higher than generic value, and upon these, with dental and cranial characters, have been founded the extinct genus *Goniopholis* (*ante* vol. i, p. 199).

Similar parts of the osseous and dental system, from Wealden formations, have yielded characters of the genera *Streptospondylus* (p. 398), *Suchosaurus* (p. 433), and *Hylæochampsa* (p. 531). From the Purbeck series have been obtained evidences of species of *Goniopholis* distinct from the Green-sand and Wealden kinds, as, for example, *Petrosuchus* (p. 636), *Brachydectes* (p. 643), *Nannosuchus* (p. 646), and *Theriosuchus* (p. 650).[1]

A Crocodilian modification of the Reptilian structure had, however, been attained as early in the Mesozoic periods as the Liassic period.

Fam.—*Protosuchii.*

Liassic Crocodiles of the genera of the extinct Protosuchian family are characterised, like most of their successors in subsequent Secondary periods, by biconcave

[1] More complete evidences of structure than those first acquired and on which the genera *Cetiosaurus*, *Poikilopleuron*, were referred to the Crocodilian Order, have now shown that the species of those genera were more nearly allied to the *Dinosauria*.

centrums, the primitive piscine form of vertebra under modifications, usually of a more consolidating kind, still prevailing. But the Protosuchians combined therewith jaws, longer and more slender than in existing Crocodiles and Alligators, armed with slender, conical, sharp-pointed and equal teeth, adapted like those of the existing Gavials, to the seizure and destruction of fishes.

The Protosuchian species fall into two genera, characterised by the position and aspect of the external nostril, which aperture in one—called *Steneosaurus*—is situated a little behind and above the anterior termination of the upper jaw, in the other—called *Teleosaurus*—the nostril is at that end, or is 'terminal,' and looks more directly forward.

Genus—Teleosaurus.

Species—*Teleosaurus Chapmanni*, Plate 15 (*Crocodilia*), figs. 2, 2 *a*.

The extinct reptile from which the characters of the genus *Teleosaurus* are derived, is one of the earliest of the evidences of ancient Reptilia which is recorded in a scientific publication. A brief description and figures of an incomplete skeleton found in the lias (alum schale) of the Yorkshire coast, about half a mile from Whitby, were published by Messrs. Wooller and Chapman, in two separate communications, in the 50th volume of the 'Philosophical Transactions,' 1758 (Pt. 2, pl. xxii and xxx). Their figures exhibit a contorted and incomplete vertebral column, about 9 feet long, and a cranium, slightly displaced, 2 feet 9 inches in length. About ten vertebræ of the lumbar and sacral region of the trunk, and twelve vertebræ of the tail, remain in place; the cervical, dorsal, and middle coccygeal vertebræ were indicated only by their impressions, and these are fewer in number than the vertebræ in the existing Crocodiles. The skull is reversed, presenting its basal surface to view; the single occipital condyle, the zygomatic arches, terminated behind by the strong tympanic bones, and the large convex articular surface in each of these, for the lower jaw, placed in the same transverse line as the occipital condyle, are all recognisable. The skull appears to contract gradually to a pointed muzzle, but in reality to the base of a long and slender maxillary beak. In the remaining basal or posterior portions of the jaws the sockets of the teeth are seen separated by intervals of about 9 lines; in some of these there are pointed conical teeth which cross alternately those of the opposite jaw. The teeth are covered with polished enamel.

Each of the vertebræ is 3 inches in length. Near the pelvic region, a portion of the shaft of the femur, including the head, was exposed, measuring between 3 and 4 inches in length. A few fragments of ribs were found near the dorsal vertebræ. The authors of the papers just analysed perceived sufficient resem-

blance between their fossil and the skeleton of the Crocodile to refer it to that family of reptiles; but their figures and descriptions gave rise to various opinions respecting the affinities of the Whitby fossil in the writings of subsequent naturalists and anatomists. Camper, for example, pronounced it to be a whale, perhaps meaning a dolphin; for, as Cuvier remarks, the presence of teeth in both jaws at once, proves the fossil not to belong to the Balænæ, which have no teeth, nor to the Physeters, which have (conspicuous) teeth only in the lower jaw. Faujas adopted Camper's opinion, referring the fossil to the genus *Physeter*, and adding some reasons which are contradicted by the descriptions given by both Chapman and Wooller. Cuvier, in the first edition of his 'Ossemens Fossiles,' after refuting the opinion of Faujas, says, "La vérité, ainsi que nous le verrons, est que c'étoit réellement un crocodile." The subsequent analysis, to which Cuvier here refers, led him in 1812 to the conclusion that it belonged to the genus of Crocodiles, and was most probably identical in species with the Crocodile of Honfleur.

In 1836, however, when so many new and singular genera, allied to the Crocodilian family, had been added to the catalogues of Palæontology, chiefly by the labours and discoveries of English anatomists and geologists, Cuvier expresses his opinion on the fossil described by Wooller and Chapman with more caution. He says, "Il reste maintenant à savoir si c'est un crocodile, ou l'un de ces nouveaux genres découverts dans les mêmes bancs. Les os des extremités y sont trop incomplets, et la tête n'y est pas représenté avec assez de détails pour décider la question; mais les vertèbres me paraissent plus longues, rélativement à leur diamètre, que dans les nouveaux genres, et plus semblables par ce caractère à celles des Crocodiles. Ceux qui retrouveront l'original, s'il existe encore, pourront seuls nous apprendre si les autres caractères répondent à celui-la."[1]

A second specimen of a long and slender-nosed Crocodilian was obtained from the lias near Whitby, between Staiths and Runswick, in the year 1791;[2] and a more perfect skeleton was discovered in the alum shale of the lias formation at Saltwick, near Whitby, in 1824. Both these specimens so closely resemble the older fossil in all the points in which a comparison can be established, as to dissipate the remaining doubts as to the nature and affinities of the specimen from the same locality, described in the 'Philosophical Transactions' for 1758. The skeleton, discovered in 1824, is figured in Young and Bird's 'Geological Survey of the Yorkshire Coast,' 2nd edit., 1828, pl. xvi, fig. 1, p. 287, and in Dr. Buckland's 'Bridgewater Treatise,' vol. ii, pl. xxv. It is now preserved in the museum at Whitby, where I have closely examined it. In this specimen are preserved the cranium, wanting the snout, the whole vertebral column, the ribs, and the principal

[1] "Recherches sur les Ossemens Fossiles," tom. 5eme, 2de partie, p. 114; 4to, 1824.

[2] See 'History of Whitby,' vol. ii, pp. 779, 780.

parts of the four extremities, together with the dorsal and part of the ventral series of dermal bones. The entire length of the skeleton, following the curvature of the spine, is 15 feet 6 inches, to which may be added 2 feet 6 inches for the lost snout. The cranium posteriorly is broad, depressed, and square-shaped; it begins to contract anterior to the orbits, and gradually assumes the form of the narrow depressed snout: the converging sides of the maxillæ are concave outwardly. The zygomatic spaces are quadrilateral, longer than the upper temporal openings, and these are longer in the axis of the skull than transversely. The orbits are subcircular; they look upwards and slightly outwards; their margins are not raised, and their interspace is slightly concave. The parietal bone is relatively longer than in the Gavial, and sends up a longitudinal median crest, from the posterior part of which a strong process extends on each side outward, and curves slightly backward, parallel with the ex-occipitals, to join the mastoid and tympanic bones, the latter of which expands as it descends to form the joint for the lower jaw.

	Feet.	In.	Lines.
Breadth of posterior part of skull	1	0	0
Length of parietal crest	0	6	0
Breadth of the interorbital space	0	3	2
Antero-posterior diameter of the middle of tympanic pedicle . .	0	2	5
Vertical diameter of orbit	0	2	0
Antero-posterior of orbit	0	3	0
From lower margin of orbit to alveolar border	0	1	3

From these dimensions it may be calculated that the entire length of the skull must have exceeded 4 feet 6 inches.

The skull of one of the Caen *Teleosauri* measures 3 feet 4 inches, whence Cuvier calculates the entire length of the animal at near 15 feet. The Whitby Teleosaur agrees with the Caen species, and differs from the Gavial in the following particulars (*Crocodilia,* Pl. 1, vol. ii). The anterior frontal is less extended upon the cheek; the lacrymal is much more extended, and is larger at its base; the malar bone is more slender. The post-frontal, which separates the temporal from the orbital cavities, is much longer and narrower. The parietal and occipital crests each form a thin trenchant plate, and are not flattened above. The mastoidean angle is not uninterruptedly united with the back part of the articular process of the tympanic, it is separated from it by a large depression, which is overarched by a trenchant crest belonging to the exoccipital. The mastoid has a concavity at its descending part, of which there is no trace in the Gavial. The indentation between the articular process of the tympanic and the tuberosity of the basioccipital is much smaller than in the Gavial, and the basilar tuberosity projects downwards in a less degree. The pterygoid ala is not expanded externally, as in all Crocodiles, but is contracted by a large fissure at the part where it goes to unite itself to the bone;

the orbital margin of the malar is not raised, and does not leave behind it a deep fissure as in the Gavial. The malar does not rise to join the postfrontal at the level of that bone, but this descends to join the malar at the external margin of the orbit. The vacuity between the orbit and mastotympanic is much elongated in the fossil, and occupies four fifths of the temporal fossa; the anterior part of this fossa is narrow and acute. The columella or ossicle of the ear is cylindrical, and much larger in proportion than in any known Crocodile or other reptile.

Cuvier calculates the number of teeth in the *Teleosaurus Cadomensis* to be 180, viz. $\frac{45-45}{45-45}$. The *Teleosaurus Chapmanni* has at least 140 teeth. The Gavial has 112, or $\frac{28-28}{28-28}$.

The teeth of the Whitby Teleosaur are as slender and sharp-pointed, but not so compressed, as in the Gavial; they correspond with those of the Caen Teleosaur, and equally illustrate the dental characters usually attributed to the present extinct genus.

The Whitby Teleosaur differs from the Caen Teleosaur, as does the Monheim Teleosaur,[1] in having the upper temporal fossæ longer in proportion to their breadth; but it differs from the Teleosaurs of both Caen and Monheim in the more equal size of the teeth, and from the Monheim species in the greater number of teeth, the *Teleosaurus priscus* having at most $\frac{27-27}{26-26}$=106. The median frontal in the Whitby Teleosaur is slightly concave, in the Caen species it is flat. The basi-occipital is perforated by the common terminal canal of the Eustachian tube close to the junction with the sphenoid, and on each side of the hole it expands into a rough tuberosity. The body of the sphenoid is compressed, characterised by two processes or narrow ridges, continued one from each side of the middle of the sphenoid obliquely backwards. The pterygoid bones are relatively smaller than in the Gavial. The palatine bones are more extended posteriorly, and articulate with the transverse bones. The posterior apertures of the nasal canals are placed more forwards upon the base of the skull than in existing Crocodiles.

Vertebral Column.—The number of vertebræ in the true Crocodiles of the present period rarely exceeds sixty, which is the number originally assigned by Ælian to the spinal column of the Crocodile of the Nile. Cuvier generally found 7 cervical, 12 dorsal, 5 lumbar, 2 sacral, and 34 caudal vertebræ.

In the *Crocodilus acutus* a thirteenth pair of ribs is occasionally developed, and, according to Plumier, it has two additional caudal vertebræ.

The Alligator (*Alligator Lucius*) has 68 vertebræ, the additional ones being in the caudal region.

The Gavial has 67 vertebræ, disposed as follows:—7 cervical, 13 dorsal, 4 lumbar, 2 sacral, and 41 caudal vertebræ.

The more perfect specimen in the Whitby Museum displays the number of the

[1] *Crocodilus priscus*, Soemmerring.

vertebræ through the whole spinal column, and establishes another difference between the Teleosaur and the Gavial, the former having a number of vertebræ intermediate between the Crocodiles and Gavials, viz. 64, with a special peculiarity in the excess of costal vertebræ, as the following formula indicates, viz. 7 cervical, 16 dorsal, 3 lumbar, 2 sacral, 36 caudal.

In all sub-genera of existing Crocodiles, as in the extinct tertiary species, the hind surface of the vertebra is convex, the fore surface concave, except in the atlas and the two sacral vertebræ.

Cuvier, who had the opportunity of seeing only the annular part (neurapophyses) of the cervical vertebræ of the Caen Teleosaur, regrets his inability to state whether either of the articular extremities of the centrum were convex, or which of them.[1] The Whitby Teleosaur decides this question, and shows that both articular extremities of the vertebræ are slightly concave in the cervical as in the rest of the vertebral series.

The atlas in the Teleosaur corresponds essentially with that of the Crocodiles, as is shown by the three main component parts of this bone from a Whitby Teleosaur in Lord Enniskillen's collection. The hypophysial centrum is a transverse quadrilateral piece, smooth and convex below, narrowing like an inverted wedge above, with six articular facets, viz. a concavity in front for the occipital condyle, a flat rougher surface on each side of the upper part for the attachment of the neurapophyses, a posterior facet for the anterior part of the true centrum, or 'odontoid element' of the axis, and the small surface on each lateral, posterior, and inferior angle for the atlantal ribs. The neurapophyses are pyramidal processes, with their apices curved towards each other; they are relatively smaller in proportion to the centrum than in the Crocodiles.

The general anterior concavity for the reception of the occipital tubercle is formed at its circumference by the hypophysial centrum and neurapophyses of the atlas, and at its middle by the anterior detached odontoid, here evidently the homologue of the atlas in the *Ichthyosaurus*, the hypophysial centrum of the atlas in the Teleosaur representing the first inverted wedge-shaped bone in the Ichthyosaur. The spine of the atlas is a large, strong, oblong piece, articulated with the neurapophyses of the atlas, and partly overlapping those of the axis.

The cervical vertebræ have strong transverse processes, a parapophysis developed from each side of the centrum, and a diapophysis from the base of each neurapophysis. The postzygapophyses look obliquely downward and outward, the prezygapophyses obliquely upward and inward. The spine is compressed, its base coequal with the whole antero-posterior extent of the neurapophysis, its height equal to the distance from its base to the diapophysis; it inclines slightly backward,

[1] 'Ossem. Fossiles,' 4to, 1824, tom. v, pt. ii, p. 137.

and is rounded off at the summit. The pleurapophysis, or rib, is bifurcate at its vertebral end, the tubercle being as long as the head and neck; its distal end is expanded into the hatchet shape, the posterior angle being most produced, and overlapping the pleurapophysis of the next vertebra behind. The same mechanism for fixing and strengthening the neck thus existed for the advantage of the ancient marine Crocodiles, as we find in those of the existing epoch.

In the dorsal region the ribs exchange the hatchet for the ordinary lengthened form, and soon begin to lose the head and neck, as in existing Crocodiles; after the fifth they no longer articulate with the centrum, only with the diapophysis, which increases in antero-posterior extent and thickness, and presents an oblique notch at its anterior angle, for the reception of the tubercle, now the only head of the rib. The number of the dorsal ribs exceeds that of any existing Crocodilian, being, as above indicated, 16 pairs. The spinous process is proportionally strong; in the Whitby specimen it measures in most of the dorsal vertebræ 2 inches in antero-posterior extent, and 7 lines in transverse diameter or thickness; the height of these spines seems not to have much exceeded that of the cervical spines, but they are more truncated at the summit.

A posterior dorsal or lumbar vertebra of a Teleosaur from the Whitby lias, in the collection of Mr. Ripley, corresponds with the vertebral characters of *Teleosaurus* in the slight concavity and circular contour of the terminal articular surfaces of the body, and in the great antero-posterior extent of the spinous processes; but that of the diapophysis does not exceed one half the length of the body of the vertebra, which is 2 inches 6 lines. This process is supported by two short, obtuse, slightly developed ridges, which rise from the upper part of the side of the body, as far apart as to include one third of the length of the body between them, and converge to the under part of the process; a similar ridge extends from the upper part of the posterior end of the process obliquely backward to the base of the postzygapophysis. The neural arch is anchylosed to the centrum in this vertebra. The supporting buttresses of the diapophyses are not described by Cuvier in the dorsal vertebræ of the Caen Teleosaur; nor have I met with any dorsal or lumbar vertebræ of the Whitby species, except the present, that was sufficiently perfect to exhibit this character; it may, however, be constant and characteristic of the genus. It faintly indicates one of the most striking characters of the vertebræ of *Streptospondylus*. The anterior and posterior margins of the spinous processes are slightly excavated, and thus retain a character which is transitory in the Crocodile, and peculiar to an early period of its existence.

The bodies of all the vertebræ are compressed laterally, and concave antero-posteriorly at the sides; but this character is more strongly marked in the anterior caudal vertebræ, which are flattened along the inferior surface; these vertebræ in the Whitby specimen were 2 inches 8 lines in length. The diapophyses are

longer, but narrower antero-posteriorly than in the lumbar or dorsal vertebræ. The hæmapophyses are united at their peripheral end, forming chevron bones, but are detached at their central ends which are articulated, as in recent Crocodiles, with the interspaces of the vertebral centres. The caudal vertebræ progressively diminish in every diameter, save length, from the middle to near the end of the tail; the terminal vertebræ are shorter than the rest.

The sternum and sternal ribs closely agree with the ordinary Crocodilian type. I have not yet seen a specimen of the abdominal sternal ribs.

Pectoral extremities.—The scapula and coracoid resemble, in general form, those of the Crocodile, but are relatively smaller, in correspondence with the smaller size of the anterior extremities. The *scapula*, for example, is only one third the length of the femur; it is straighter than that of the Crocodile; both margins are nearly equally concave, instead of the anterior one being convex; the humeral end is less expanded, and is more obliquely truncated. The *coracoid* is longer than the scapula, instead of being, as in the Crocodiles, shorter; this probably depends upon the breadth of the fore part of the body, which regulates the extent of the coracoid, while the proportions of the scapula more exclusively depend upon the development of the pectoral extremity. The coracoid of the Teleosaur differs also from that of the Crocodile in the greater expansion of its humeral end, the more transverse position of its sternal convex extremity, and a nearer approach to parallelism in the direction of the two lateral margins. (*Crocodilia*, Pl. 1.)

In the Whitby Teleosaur, discovered in 1824, the humerus of the right anterior extremity, and the humerus and bones of the fore-arm of the left (Pl. 15), are preserved nearly in their proper relative positions. The humerus is shorter in proportion than in the Crocodiles, its length scarcely exceeds the antero-posterior diameter of two of the cervical vertebræ. The antibrachial bones are still more curtailed in their proportions; the longest bone, or ulna, being not quite half the length of the humerus.

No portions of the carpal or other bones of the paddle are preserved, but the presence of the antibrachial bones, distinct from each other, and of the ordinary form and breadth at the distal end, forbid our supposing them to have been naturally deficient or of abortive proportions in the *Teleosaurus*. Admitting the humerus, radius and ulna to have existed for a purpose, that purpose, we may conclude, from the modifications for an aquatic life in the rest of the skeleton, to have been the support and movement of a palmated manus; an organ which would be of great use in turning and regulating the course of the swimmer and in bringing the long and slender snout, with the terminal nostrils, to the surface. The fore-paddles were doubtless much smaller than in ordinary Crocodiles, and this difference of proportion related both to the less frequent resorting of the

Teleosaur to dry land, and to the light and slender character of its jaws and teeth with the consequent diminution of the weight of its head. (*Crocodilia*, Pl. 1.)

Pelvic extremity.—The pelvis of the Teleosaur was attached, as in the Crocodile, to the thickened and expanded transverse processes of two sacral vertebræ. These processes are stronger in the vertical direction, and intercept a relatively smaller and more regularly elliptical space than in the existing Crocodiles; the anterior one appears not to have been so much expanded in the antero-posterior direction. The iliac bone seems to have been shorter in the antero-posterior diameter, but longer, as measured transversely to the axis of the trunk, and thus to have made a slight approach to its characteristic form in the Enaliosaurs.

Both the ischium and pubis are relatively more expanded than in the Gavial. The pelvic extremities are preserved in the Whitby specimen in nearly their true relative positions; but the right is thrown directly over the left. The femur presents the usual form but is relatively more slender than in the existing Crocodilians; it is slightly twisted, and bent in two directions. Its proximal end is expanded, compressed with a regular convex curve, describing a semi-circle; the trochanter is represented by a ridge which gradually subsides, and is lost upon the surface of the shaft. This is nearly cylindrical at the upper part, but is produced at the anterior or convex side along the distal half in the form of an obtuse ridge. The condyles are very feebly indicated. In the Whitby specimen of 1824,

	Feet.	In.	Lines.
The length of the femur is	1	3	3
The breadth of proximal end of ditto	0	2	10
The diameter of middle of shaft	0	1	4

Both the tibia and fibula are subcompressed towards their distal end: the length of each bone is 8 inches. The shaft of the fibula is nearly as thick as that of the tibia. The bones of the leg of the *Teleosaurus* resemble those of *Aëlodon* in their relative shortness as compared with the femur. In these, and probably in other ancient Crocodiles with biconcave vertebræ and marine habits, the tibia is little more than half the length of the femur; while in recent Gavials it is two thirds that length. There are five tarsal bones, two in the proximal and three in the distal row, as in the Gavial; but they are of more equal size; the two proximal bones being by no means so disproportionately large. All the long bones have distinct medullary cavities, and these are even present in the metatarsals. In the Whitby specimen,

The length of the middle metatarsal is	6 inches.
The breadth of its proximal end	10 lines.
The breadth of its distal end	6 ,,

The ungual phalanges are depressed, smooth, and convex above, rounded at the end.

Dermal armour.—The bony dermal scutes of the Teleosaur were regularly disposed like those of existing Crocodiles, in both longitudinal and transverse series; the posterior margin of one scute covered the base of the succeeding scute,[1] and they slightly overlapped each other laterally.

Cuvier states that one of the fossils of the *Teleosaurus Cadomensis* presents all those of one side in their natural situation, exhibiting, in the part of the body included between the first dorsal and the beginning of the tail, fifteen or sixteen transverse rows, containing five scutes on each side; so that there were at least ten longitudinal rows of these dermal bones.

The scutes are arranged in the same manner and number, at least as regards the transverse rows, in the Whitby Teleosaur; these rows being indicated by the large dorsal scutes still occupying their natural position in an uninterrupted line along the back; they are twenty in number, and sixteen cover the vertebræ included between the last cervical and first caudal (Pl. 15).

The scutes of the *Tel. Chapmanni* differ as much from those of the existing Gavials and Crocodiles as do those of the *Tel. Cadomensis*, being thicker, rectangular, and having the outer surface impressed with circular pits or indentations from 3 to 4 lines in diameter which are not confluent, but separated.

The median dorsal scutes of the Whitby specimen are nearly square, having the longer diameter, about $3\frac{1}{2}$ inches across, placed transverse to the axis of the body, and with the outer margin slightly rounded. Each of these scutes is traversed, as in the *Tel. priscus*, by a longitudinal ridge, which is less developed than in the Gavials. The median dorsal scutes of the *Tel. Cadomensis* and *priscus* appear to differ from those of the *Tel. Chapmanni* in being more oblong transversely, and with the posterior and lateral margins rounded off. Cuvier does not allude to the carinated character of these plates in the Caen species.

The lateral and ventral scutes of the *Tel. Chapmanni* are more perfect squares than those next the spine, but differ less in form and size from them than in the Caen Teleosaur. They are marked externally by the same impressed pattern, but are not carinated. The median abdominal scutes are not opposite but alternate; their median margins are rounded off, or slightly angular; and, while the anterior part of that margin is overlapped by the posterior half of the opposite scute, in advance, the posterior half overlaps the succeeding scutum of the opposite side. The verticillate cuirass of these ancient Crocodiles is thus securely braced round the trunk by this interlocking of the inferior extremities of each ring

[1] Cuv., l. c., p. 279.

of scutes, whilst the imbricated arrangement would allow of a certain sliding motion of the rings upon each other sufficient for the expansion of the chest in breathing. The scutes in the fine specimen in the Whitby Museum measure about 5 lines in thickness, but are thinned off at the edge.

Having now detailed the anatomical particulars which a study of the magnificent and unique skeleton of the *Teleosaurus*, in the museum at Whiby, has enabled me to add to the previous descriptions, by Cuvier and other anatomists, of the osteological structure of this extinct Crocodilian genus, I next proceed to notice the principal examples of the same genus which are preserved in other collections of British Fossil Reptiles.

The first of these is a fine skull of the same species of *Teleosaurus*, and from the same lias beds near Whitby in the museum of Mr. Ripley of that town:

	Feet.	Inches.
The length of the entire skull is	2	9
From the angle to the beginning of the long symphysis of the lower jaw .	1	3
Breadth of the lower jaw at the posterior commencement of symphysis . .	0	$2\frac{1}{2}$
Breadth of the extremity of the lower jaw	0	1

The extremity of the upper jaw well exhibits in this specimen the characteristic generic modification of its infundibuliform expansion, supporting the terminal nostrils, and resembling the extremity of the elephant's proboscis, wanting the digital process.

This cranium also clearly exhibits the specific characters by which the *Tel. rus Chapmanni* of the Yorkshire lias differs from the *Tel. Cadomensis* of the Caen oolite, viz. the greater antero-posterior extent of the upper temporal openings as compared with their transverse diameter in the *Tel. Chapmanni;* the similar but slighter difference in the form of the orbits, the greater breadth of the interorbital space, which slightly exceeds the transverse diameter of the orbit instead of falling short of that diameter, as in the *Tel. Cadomensis*.

A cranium of the *Tel. Chapmanni*, in the museum of the Philosophical Institution at York, and another in the museum at Scarborough, offer the same specific characters as the Whitby specimens. In the Scarborough cranium the diameter of the orbit is 2 inches 3 lines, while that of the interorbital space is 2 inches 6 lines.

In the museum of the Natural History Society at Lancaster there is a chain of five dorsal vertebræ of the *Tel. Chapmanni*, from the Whitby lias, measuring 1 foot in length; each vertebra is 2 inches 4 lines in length. A section of these vertebræ showed a small cavity in the centre of the cancellous structure of the body.

Teleosaurus Cadomensis.—Specimens of fragments of the jaw, teeth, and vertebræ

of this species have been discovered in the Bath oolite at Enslow, near Woodstock, and in the oolite at Stonesfield.

Teleosaurus Cadomensis (var.).—Of this species, which is nearly allied to, if not identical with *Cadomensis*, I have examined a posterior cervical vertebra from the oolite near Chipping Norton, in the collection of Mr. Kingdon of that town. The sides of the centrum are less compressed than in the *Tel. Chapmanni*, and the articular extremities have a more circular contour, the transverse exceeding the vertical diameter. There is no appearance of a ridge along the under surface: the transverse process of the centrum arises close to the neurapophysis.

	Inch.	Lines.
The length of this vertebra is	1	5
Transverse diameter of centrum	1	3
Vertical diameter of centrum	1	$1\frac{1}{2}$

Species—*Teleosaurus brevior* (*Crocodilia*, Pl. 16).

In *Teleosaurus Chapmanni* (Pl. 15) the skull, from the fore part of the orbit to the end of the snout, includes four lengths of the cranium behind that part of the orbit; in *Tel. brevior* the part of the skull anterior to the orbit includes but two lengths and a half of the portion of the cranium behind that part of the orbit. The upper temporal apertures are subquadrate, the longitudinal diameter being the longest. The orbit is circular, but relatively smaller than in *Teleosaurus Chapmanni;* as in that species the plane of its outlet is more oblique than in tertiary Crocodilia; it combines a lateral as well as upper outlook. In tertiary species only the upper third of the cavity is seen in a profile view (compare fig. 1, Pl. 16, with fig. 1, Pl. 1 B, *Crocodilus Hastingsiæ*). In advance of the orbits, in *Tel. brevior*, as in the type species (*Tel. Chapmanni*), are the orifices representing the outer nostril in *Enaliosauria*.

As in modern and tertiary *Crocodilia*, the hinder third of the mandible shows a large vacuity; but the splenial element, 31 (fig. 13, p. 97, vol. i), enters into the fore border of the vacuity in a larger proportion than in those later species. The massive paroccipito-mastoid productions are proportionally shorter (compare fig. 3, Pl. 16, with fig. 2, Pl. 1 A); the descending portions of the basioccipital are also shorter in proportion to their breadth, and are more definitely notched below; the masto-parietals are longer, their free ends being more produced and slender.

The proportion of the upper jaw retaining its smallest breadth is much less in length than in *Tel. Chapmanni.* The breadth of the produced slender portions of both upper and lower jaws is relatively greater to their length than in *Tel. Chapmanni.* The teeth are similar in shape, relative size, and number, to those of the type species, regard being had to the shorter jaws.

The specimen figured is from the Lias of Whitby, and is now in the British Museum.

Species—*Teleosaurus latifrons*, Owen (*Crocodilia*, Pl. 17).

The proportions of the cranial and facial parts of the skull in *Teleosaurus Chapmanni* (Pl. 15) are defined in the characters of the preceding species. In *Tel. latifrons* the part of the skull anterior to the orbit includes three times the length of the upper part of the cranium behind the fore part of the orbit. The entire length of the skull in the present species is about three times its greatest breadth, that is, taken across the back part of the temporal vacuities. In *Tel. Chapmanni* five times that breadth are included in the total length of the skull. Thus, in its general proportions *Teleosaurus latifrons*, like *Tel. brevior*, approaches near to the Geoffroyan genus *Steneosaurus*, but the terminal, almost vertical external nostrils, the antorbital vacuities, with the relative slenderness of the produced upper and under jaws, are strictly teleosaurian.

The occipital surface, viewed from above, describes a more regular concave curve than in *Tel. Chapmanni* or *Tel. brevior*, the frontal region between the orbits is broader, both absolutely and relatively, to the skull's length, suggesting the specific name. The parietal division of the temporal vacuities has been reduced by long exercise of the muscular masses therein lodged to a ridge, the walls of which diverge slightly at the fore part to give issue to the cerebral production traversing the "foramen pineale." The mastoid and squamosal supports of the tympanic joint are marked respectively by the letters *o* and *n*, fig. 1. From the squamosals, the sides of the skull converge with a gradual and gentle curve to the maxillary elements of the upper jaw. The nasals terminate anteriorly, by their usual pointed inter-union, at the middle of the skull's length.

The form of the transverse section of this part is added to figure 2 (palatal surface of skull); also a similar section is shown, taken across the hinder-pointed ends of the premaxillarics. In advance of these the premaxillaries are slightly constricted laterally, but the fossil fails to give satisfactory indications of large inferior canines as the cause. Anterior to these the premaxillaries expand, and so surround the outer nostrils as to give them the almost vertical teleosaurian position. The palatal surface of the mandible and two sections are shown in fig. 4, Pl. 17.

The specimen above described and figured is from the oolite of Northamptonshire.

Species—*Teleosaurus asthenodeirus*, Owen.

If the cranium of this Saurian should correspond with the characters of the

genus which are exhibited by the vertebræ and scutes here described, a distinct species is very evidently indicated by them, characterised by the smaller size of the cervical ribs, and the consequently weaker structure of the neck.

In the Oxford Museum are preserved two cervical vertebræ and a dermal bone of this species, from the Kimmeridge clay at Shotover. The articular extremities and general form of the body of the vertebræ accord with the Steneosaurian type.

	Inches.	Lines.
The length of the centrum is	2	2
Vertical diameter of articular end	1	6
Transverse diameter of articular end	1	5
Antero-posterior extent of lower transverse process	0	6

This process arises near the lower surface of the centrum, about half an inch from the anterior extremity of the bone. It is separated about the same distance from the upper transverse process, which is continued from the base of the neurapophysis; both the supports of the cervical rib are one third smaller than the corresponding processes in the *Teleosauri Chapmanni* and *Cadomensis*, and are less extended from the sides of the vertebra.

The dermal scute is devoid of a ridge; one half of the external surface is pitted with well-defined hemispherical depressions, separated from each other by about half their breadth, the smallest being nearest the margin; the other half of the scute is smooth, and indicates that it was overlapped by the adjoining scute, according to the characteristic disposition of this fish-like covering of the present extinct marine genus of Crocodilians.

Species—*Indeterminata*.

In the Hunterian Collection are two entire dorsal vertebræ, with part of a third, fractured through the middle of the body, and displaying a small cancellated cavity filled with calcareous spar, as in the *Teleosaurus Chapmanni*. These vertebræ present the slightly concave articular extremities, and the other characters of the genus *Teleosaurus*. The length of the centrum, measured along the under surface, is 2 inches 6 lines; vertical diameter of articular end 2 inches; transverse diameter 1 inch 10 lines; transverse diameter of the middle of the body 1 inch. Both the inferior and lateral surfaces of the body are regularly concave, lengthwise; and smooth, except near the expanded articular extremities, where they are striated in the axis of the vertebra.

The antero-posterior extent of the transverse process is 1 inch 6 lines; that of the base of the spinous process 1 inch 9 lines. The transverse diameter of the spinal canal 7 lines; its vertical diameter $4\frac{1}{2}$ lines.

These vertebræ are cemented together by a matrix, which closely resembles the gray Kimmeridge clay; and a portion of a species of *Pecten* is attached, which is one of the characteristic fossils of the oolite group of secondary rocks, especially the Oxford clay.

Genus—Steneosaurus, Geoffroy.

Cuvier, after his instructive account of the remains of the "Gavial des carrières de pierre calcaire des environs de Caen,"[1] to which Geoffroy St. Hilaire attached the name *Teleosaurus*, proceeds to describe the remains of another Gavial-like Crocodile from a different, but oolitic, locality.[2]

On these subjects Geoffroy St. Hilaire remarks[3]: "Je termine cette première lecture en prévenant que des objets representés en la planche vii des '*Ossemens Fossiles*,' il n'y a l'applicables au *teleosaurus* que les sujets figurés sous les nos. 1, 2, 3, 4, 5, 10, 11, 12, 14, et 17. Les autres objets (figs. 6, 7, 8, 9, et 13, 15, 16) venaient de plus loin de Quilly; ils proviennent d'une autre espèce, se rapportant à un autre genre que j'ai déja determiné et nommé.[4] J'en traiterai ultérieurement sous la denomination de *steneosaurus*."

Of the figures illustrative of this genus are selected, for the present work, Cuvier's fig. 8 (Pl. 20, fig. 6), representing the palatal surface of the upper jaw, one fourth of the natural size, and Cuvier's fig. 13 (Pl. 20, fig. 5), representing the upper surface of the fossil skull one twelfth of the natural size; they represent the types of the genus.

To the characters of *Steneosaurus*, thereon founded, I have been able to add those of the better preserved specimens, from the same geological zone, of a British locality, in Plate 18 (*Crocodilia*).

Geoffroy St. Hilaire recognised that the oolitic Crocodilian made a nearer approach to the Gavial than did the liassic *Teleosaurus*. The beak was relatively shorter, and the external nostril less terminal. He writes: "Nous verrons que ce genre est exactement intermédiaire entre nos *teleosaurus* et le démembrement du grand genre crocodile, dont j'ai traité sous le nom de *Gavialis*.[5]

"It has not," he rightly remarks, "a skull so long and slender as in *Teleosaurus*, but longer and slenderer than in *Gavialis*." The transition towards modern or existing Crocodiles, which Geoffroy advocates in these 'Mémoires,' is toward the

[1] 'Ossemens Fossiles,' 4to., tom. v, pt. 2, p. 127.

[2] Ib., p. 134

[3] "Divers Mémoires sur de Grands Sauriens, &c.," 'Lu à l'Acad. Royale des Sciences,' le 4 octobre, 1830, p. 26.

[4] 'Mémoires du Muséum d'histoire nat.,' tom. xii, 1825.

[5] Ib., p. 40.

Gavialic modification, not going beyond in the direction of the short and broad-jawed forms, yet not quite reduced to the proportions of cranium and face exemplified in the more nearly allied long and narrow-jawed species at present existing in the great rivers of India; Geoffroy's remarks being exemplified by Cuvier's figures, representing the Steneosaurian characters, which I have introduced into Pl. 20, (*Crocodilia*) of the present work.

Species—*Steneosaurus Geoffroyi*, Owen, *Crocodilia* (Pl. 18, fig. 1).

The mutilated cranial part of a skull (Pl. 18, fig. 1), referable to this species, from the Great Oolite of Oxford, shows the following dimensions:

	Inches.	Lines.
Breadth of hinder or occipito-mastoid surface	11	0
Height from the lower border of the occipital condyle to the parietal ridge .	4	8
Length of the temporal fossa	5	4
Breadth of ,, ,, ...	5	0

From the intertemporal or parieto-frontal crest the sides slope at once, save at the fore part, where the crest expands to one inch in breadth with a slight superior convexity; longitudinally the crest is slightly convex. The posterior boundary of the temporal fossa, formed by the parietal and mastoid bones (ib., ib., 7, 8) terminates above in a sharp ridge. The paroccipital (ib. 4) extends from the exoccipital outward to abut against the mastoid. The exoccipitals meet below at their junction with the basioccipital (fig. 2, 1) and exclude it from entering into the formation of the occipital foramen. In *Teleosaurus*, as in recent Crocodiles, the basioccipital contributes a small share to the lower border of the foramen. Above the suture, extending from the foramen outwards, the exoccipital is perforated by the precondyloid foramen, by the entojugular and the entocarotid foramina, the three being in a line extending downward and outward. The cranial canal is relatively smaller than in the Gavial and is subcylindrical.

So much of the superior maxillary bone (fig. 1, 21) is preserved as shows sockets of 3 teeth in front of, and 27 teeth behind, a short diastema; there is no groove along the mesial surface of the alveolar part. In the mandible the post-articular angle equals in extent the transverse diameter of the articular surface, approaching thus to pliosaurian proportions, whilst it is longer in the Gavial. The articular surface is convex in the middle, concave on each side, not uniformly concave as in the Gavial and modern Crocodiles; the articular element extends more forward, and is broader on the inner side of the ramus. The depth of the ramus at the coronoid ridge is greater and the ridge itself is higher. There is no vacant interval between the angular and sub-angular elements.

Species—*Steneosaurus laticeps*, Owen, *Crocodilia* (Pl. 18, fig. 2).

The breadth of the cranium in proportion to the length, measured from the occipital tubercle to the orbit, suggested the specific name. The orbits, like the temporal fossæ, approach nearer to a circle in outer contour than in *Sten. Geoffroyi*, and they have a less obliquely lateral aspect, approaching in that character nearer to the *Teleosauri;* the facial part of the prefrontal, 14, terminates in a point, at the same transverse parallel as that part of the mid-frontal, 11, and this part is relatively broader and shorter than in *Sten. Geoffroyi.* The nasals, 15, become narrower, as they advance more rapidly than in that species, and terminate in a point at some distance from the external nostril which is bounded exclusively by the premaxillaries, as in the type Steneosaur, which in this character adheres to the modern Gavial.[1]

Species—*Steneosaurus temporalis*, Owen, *Crocodilia* (Pl. 19).

This specific name was suggested by the great relative size of the temporal vacuities as indicated by their upper apertures (fig. 1, *n, n*). The powerful biting muscles originating therein have reduced the cranial interspace to a ridge.

The orbits seem to have been comparatively small; but the contour of their outlet had been mutilated in the clearance of the specimen from the oolitic free-stone (Bath) in which it was imbedded. The mastoidal process contributed to the concave mandibular joint is relatively broader than in the Teleosaur (Pl. 16, fig. 3); the occipital condyle is relatively larger; and the descending part of the basi-occipital does not show the median notch. The length of the portion of mandible (ib., fig. 4) from the angular process to the hindmost tooth-socket, indicates the proportion wanting in the interval between the cranial and orbital regions of the skull somewhat artificially joined in the Bath specimen. The outer nostril is bounded by the premaxillaries, the nasals terminating at some distance therefrom as in other Steneosaurs. The teeth, 24 on each side of the upper jaw (fig. 3), are relatively larger than in the preceding and type Steneosaurs; and, with the general proportions of the facial part of the skull, indicate a transition to the platycœlian *Crocodilia* of later mesozoic formations.

In the Woodwardian Museum, Cambridge, is a portion of the skull of a Croco-

[1] "Les os du nez, k, k, sont bien éloignés d'aboutir à l'overture des narines," 'Oss. Foss.,' tom. cit., p. 106.

dilian, with characters indicative of a Steneosaur; it is embedded in its matrix, and includes the upper part of a cranium with much of the bony roof broken away; this mutilation, however, exposes the cranial cavity, a cast of which gives a tolerably good representation of the brain of the extinct reptile. The cerebral lobes, thus shown, have the smooth convexity of those of the Crocodile, and the similarly smooth optic lobes, but little less in size, are partially represented. The length of so much of the brain is 2 inches, the breadth of the cerebrum is $1\frac{1}{2}$ inches; the breadth of the skull is $6\frac{1}{2}$ inches. The temporal fossæ form wide ellipses 2 inches 9 lines in long diameter. From the back of the cranium to the beginning of the narrowing jaws is 8 inches; the length of the skeleton may be estimated as about 18 feet.

JOHN HUNTER had acquired for his series of evidences of extinct species—so remarkable at that period—a century ago—a portion of the mandible of a Steneosaur, including six inches extent of the hind part of the symphysis: the transverse diameter of the mandible at the junction of the rami is 4 inches, 3 lines; the hind surface of this union shows a deep transversely elliptical depression. Both upper and lower surfaces of this symphysial portion of jaw are flat, and the outer sides of the rami here are nearly flat and at right angles with the horizontal surfaces, the angles being rounded off. The inferior flattened surface is impressed with small irregular longitudinal grooves, but not with pits or foramina. So much of the alveolar border is preserved in each ramus as measures $5\frac{1}{2}$ inches; the inner border rises higher than the outer one, and this tract includes eight teeth of Steneosaurian character: the diameter of the circular base of the crown is from 4 to 5 lines.

So much of the matrix as remains attached to this specimen resembles Oxford oolite. It is not without interest to see that the geologically younger *Protosuchian* shows narial and some slighter characters, by which it comes nearer to the modern gavialic modification of the order; but the species of the genus next to be described, which have left their remains in still later mesozoic deposits, make a still nearer approach to the existing forms of Crocodilian Reptiles.

Genus—PLESIOSUCHUS, *Owen*.[1]

Species—*Plesiosuchus Mansellii*,[2] *Crocodilia* (Pl. 20, figs. 1—4).

This genus and species exemplifies an interesting approach in an upper division

[1] πλεσιος, near; συχος, Crocodile (name of Egyptian species).

[2] *Steneosaurus Manselii*, Hulk, 'Quarterly Journal of the Geological Society,' vol. xxvi, p. 170, pl. ix.

(Kimmeridge Clay) of the mesozoic series to the modern *Crocodilia*, as exemplified in the genera *Crocodilus* and *Alligator*, species of which have been restored from the older tertiaries (*ante* Vol. I, pp. 112—133; *Crocodilia*, Plates 1—4).

The resemblance to these genera and difference from the genus *Gavialis* are manifested in the proportions of length and breadth of the antorbital part of the skull; and the difference from the latter existing genus and the extinct *Crocodilia* (*Teleosaurus* and *Steneosaurus*), with gavialic proportions of the skull, is exemplified in the extension of the nasal bones (Pl. 20, fig. 1, 15) to the outer nostril, *n*, and is increased by the smaller proportional number of teeth in the upper jaw, 15, (Pl. 20, fig. 2), than has been noted in any existing species of Alligator or Crocodile proper.[1]

Cuvier assigns to the latter genus 19 teeth on each side of the upper jaw;[3] and to the Alligators 19 or 20 teeth in the upper jaw.[2] In both genera, the teeth are signalised as of unequal size, " sont inégales " and this character, as illustrated in Cuvier's 'Planche I,' is more marked than it could have been in *Plesiosuchus* judging from the series of sockets, and the absence of the premaxillo-maxillary constrictions, shown by those recent species (*Crocodilus vulgaris*, *Croc. acutus*) which the fossil most resembled in the shape of the skull (Pl. 20, fig. 1).

The narial character which distinguishes the gavialic *Teleosaurus* and *Steneosaurus* from the Crocodilian fossils is shown in Plate 1, fig. 1*a*, *Gavialis*, and fig. 2*a* *Teleosaurus*, which may be compared with Pl. A, 2, fig. 1 (*Crocodilus suchus*) and Pl. 2A, fig. 1, *Crocodilus champsoïdes*. The agreement in this respect with the latter group is exemplified in Pl. 20, fig. 1, 15 *n*.

But now comes an important, perhaps more important, character differentiating the present with all known mesozoic *Crocodilia* from all known tertiary and existing kinds, gavials not excepted. It is presented by the articular surfaces of the vertebral bodies or centrums; these instead of articulating together by ball-and-socket joints, are joined by surfaces deviating little from flatness, and that in the direction of concavity. Cuvier had recognised this character in the gavial-like fossils which he described and figured from Liassic and Oolitic formations; but he was not moved thereby to frame for them generic names.

Of the vertebral body in his 'Gavial de Caen' (*Teleosaurus*, Geoffroy) Cuvier states:—" Il a ses deux faces très-legérement concaves, et son milieu retréci." (Op. cit., p. 137), and he remarks:—" C'est là, comme on voit, un caractère fort différent de celui des crocodiles vivans, où toutes les faces postérieures sont très-convexes et les antérieures très concaves " (Ib., ib.)

[1] " Les CROCODILES—*proprement dits*—ont quinze dents de chaque côté en bas, dix-neuf en haut," 'Ossemens Fossiles,' tom. v, pt. ii, 4to, p. 31.

[2] " Les CAIMANS (*Alligator*) ont, au moins, dix-neuf et quelquefois jusqu'à vingt-deux de chaque côté en bas; au moins, dix-neuf, et souvent vingt en haut," Ib., p. 30.

Fortunately portions of two vertebræ are included in the mass of matrix still adherent to the skull of *Plesiosuchus*.

The first is a centrum of a mid- or post-dorsal vertebra (Pl. 20, fig. 3) lodged in that part which obscures the base of the skull; it gives a length of 3½ inches; a vertical (posterior) breadth of 3 inches; the transverse breadth seems not to have exceeded 2 inches at the middle of the centrum. The preserved portion of the base of the neural arch shows that the parapophysis had disappeared or risen into confluence with the diapophysis, indicating the region of the spine from which this vertebra has been derived. The character of the terminal articular surfaces of the centrum removes this form of mesozoic Crocodile from the tertiary or neozoic genera. Both surfaces are slightly concave, the fore one nearly approaching to flatness.

The degree in which the skull conforms to the proportions characteristic of Cuvier's genus *Crocodilus* proper,[1] differentiates it from the gavial-like genera *Teleosaurus* and *Steneosaurus*, and the narial character above referred to more decisively separates it from the latter, with which it has been confounded. I am, therefore, constrained to append a name to the extinct genus which the Kimmeridgian specimen represents, retaining the specific name applied to it by Mr. J. W. Hulke. I regret that having to record it, agreeably to the wish of my friend Mr. Mansell Pleydell, in the concluding volume of the present Work, with consequent unavoidable delay, gave the opportunity of a fellow-labourer in Reptilian Palæontology to make the specimen known, and, in anticipation, to append to it a generic name, which if applicable, I should have felt bound to retain.[2]

A second vertebra includes, with part of the centrum, the neural arch and spine. The latter shows its obtuse free termination. The total height of this vertebra is 9 inches; that of the neural arch, spine inclusive, is 6½ inches; the neural spine along the fore part is 4 inches; along the hind part from the base of the postzygapophyses it measures 3 inches; the thickness of the spine is 1 inch; the broad base of the broken diapophysis is 2 inches. This process projects from near the base of the neural spine. The vertebral characters bespeak a platycœlian Crocodile of great power, in concordance with the formidable array of teeth.

The length of the maxillo-premaxillary alveolar tract (Pl. 20, fig. 2) is 1 foot, 8½ inches; it includes 16 teeth on each side, of which 3 are supported by the premaxillary, and the rest, after an interval of 9 lines, by the maxillary bones. Of

[1] As exemplified in *Crocodilus acutus*, tom. cit., p. pl. i, fig. 3.

[2] "A closer examination lately made by Mr. Davies, sen., of the fossils presented to the British Museum last year by J. C. Mansel, Esq., has led to the identification of a large Crocodilian head—this head had been previously put aside as Pliosaurian" (Hulke, 'Quarterly Journal of the Geological Society of London,' vol. xxvi (1870), p. 167).

That this collection included Pliosaurian remains from the same Kimmeridgian bed is true; but that the Crocodilian head was referred by any authority of mine to the *Sauropterygia* is incorrect.

the premaxillary teeth the third is rather larger than the rest; the maxillary series begins by one somewhat smaller, the rest are of larger size, and maintain it to the thirteenth, the remaining two slightly decreasing; but a general uniformity prevails throughout the series. The base of the ninth tooth has a diameter of 1 inch, 2 lines, with a circular transverse section; that of the second (premaxillary) tooth gives 10 lines in the same direction.

The upper jaw, with a basal breadth of 7 inches, gradually and uninterruptedly narrows to 2½ inches across the foremost pair of sockets. The palatal interspace between these sockets does not exceed that which separates the socket of the first from that of the second tooth. This interspace seems not to have exceeded 4 lines at the alveolar outlet; the interspaces of the maxillary alveoli are so much less, that most of the teeth of the same series between the two extremes must have been nearly, if not quite, in contact basally. The breadth of the palate between the third pair of teeth is 2 inches; between the last pair it is 8 inches. The midline of the mouth-roof is slightly produced.

Portions of the broken off crowns of the teeth show the two-ridged Crocodilian character, with a smooth intervening enamel. Two of these detached crowns (ib., fig. 4) seem to indicate the extent to which the upper and lower teeth overlapped in the closed mouth; of these the best preserved gives a length of $4\frac{1}{2}$ inches. A transverse fracture of a tooth-crown, where its diameter had fallen to 7 lines, shows a pulp-cavity diminished to 3 lines.

The upper aperture of the temporal fossa is six and a half inches in transverse, and seven inches in fore-and-aft, diameters. The upper (post-fronto-mastoid) boundary curves outwardly, with a thick convex surface. The mandibular muscle, which it included, had a size conformably with the close-set series of large teeth, which it worked.

The frontal bones, 11, converge to a point, ten inches distant from the premaxillary apex of the skull. The nasal bones, 15, gradually narrow to a point penetrating the hind border of the nostril, *n*. This opening is ovoid, three inches and a half in length, three inches in greatest breadth. The premaxillaries meet and join an inch and a half anterior to the horizontal nostril.[1]

The transition to tertiary and existing Crocodiles is manifested by the proportions of the skull and of the teeth; but these, in the degree of general equality of size, are gavial-like, while in relative size and paucity of number they show the Crocodilian character in excess.

There is no trace of an alveolar pit in the upper jaw for the reception of a lower canine, as in the Alligators, nor of any lateral notch for such a tooth as in

[1] "Les intermaxillaires, *a*, *a* (figs. 1, 2, 3), entourent les narines externes, excepté un endroit fort étroit où la pointe des os nasaux, *k*, *k*, se place entre eux." "Détermination des os de la tête dans les Crocodiles proprement dits." 'Ossem. Fossiles,' v, pt. ii, pp. 69, 71.

the Crocodiles. The general equality of size in the tooth-crowns seems a remnant of the earlier mesozoic dental character; but the number of teeth is even less than in any known modern Crocodile or Alligator. Of the latter the species which I have examined show eighteen teeth on each side of the upper, and as many teeth on each side of the lower jaw. Of *Crocodilus* (Cuv.), I have not seen any species with fewer than eighteen teeth on each side of the upper, and fifteen on each side of the lower jaw. In no instance is so small a number recorded as sixteen teeth on each side of the upper jaw, characteristic, as far as the present unique skull shows, of the genus *Plesiosuchus*.

Existing Crocodiles differ from Lizards in the position and relative size of the opening, by which the breathing-passage from the nostril communicates with the roof of the mouth. The bony palatonarial aperture is single, small, and placed far back, very near the basi-occipital condyle.

Those examples of extinct Liassic and Oolitic Crocodiles in which, from parts of the fossil skull, usually fragmentary, a judgment could be formed of this character, had led me to the conclusion that both in size and less retral position the palatonares showed more resemblance to that in Lacertians, and thus gave indications of a more generalised Saurian structure.

Cuvier, in his description of a fossil skeleton of a Crocodile (*Steneosaurus*, Geof.) from the Caen Oolite, recognised the palatonaris as a large aperture far in advance of the position it presents in existing Crocodiles.[1]

This distinctive character was, however, called in question by later Palæontologists. In the 'Abhandlungen über die Gavial-artigen Reptilien des lias-formation,' fol. 1841, by Professors Bronn and Kaup; it is argued at length (pp. 12, 16, 24) that the posterior median foramen is the true hinder or palatal aperture of the nostrils; and a letter from De Blainville is cited by those authors in support of their view, in which Cuvier's determination, that it was 'an arterial foramen,' is rejected, and Professor Bronn's opinion is stated to be completely confirmed by the appearances in the fossil skull of a *Teleosaurus* from Caen.

After an examination of the original specimen, described by Chapman, ('Phil. Trans.,' vol. l), and now in the Whitby Museum, I proceeded to compare the foramina in question with those, the true nature of which might be determined by anatomical investigation of their relations and functions in existing Crocodiles and Gavials.

The results of these dissections and injections were communicated to the Royal Society,[2] and they demonstrated the accuracy of Cuvier's ascription of the characters of a palatal nostril to the larger and more advanced vacuity in the bony palate; but they brought to light a more complex structure of the communications

[1] "La fosse nasale postérieure est très grande, et bien éloignée de ne s'ouvrir que vers l'extrémité de la face basilaire, où sont dans les crocodiles ordinaires les arrière-narines trés-peu avant le trou des artères . ." 'Ossemens Fossiles,' tom. v, pt. ii, p. 133.

[2] 'Philos. Trans.,' 1850, p. 522, plates 40—42.

between the organ of hearing and the palate, and showed that the 'foramen' which Cuvier had described as giving passage to an artery was the medial outlet of an eustachian canal, one by which the atmospheric air could pass to the tympanic cavity.

The foregoing details of the osteological and dental characters of the extinct Crocodilian reptiles of the secondary or mesozoic formations, as well as those of the tertiary Crocodiles in the first volume of the present work, testify how little was left by Baron CUVIER to be added by his disciples and successors. The combination of secondary and tertiary modifications in the structure of skull and teeth, in the Kimmeridgian *Plesiosuchus*, will probably be esteemed as the chief addition to this chapter of Extinct *Reptilia*.

It owes to Geoffroy St. Hilaire the invention and application to genera, the characters of which are exclusively due to Cuvier, of names which the founder of palæontological science cared not to give.

In my Pl. XX the two figures from the Pl. VII of the "Ossemens Fossiles" are repeated, which Geoffroy selected as characteristic of the genus he proposed to term *Steneosaurus*. But the gist of the 'Mémoires' of 1825, as of those of 1830, was to interpret the Cuvierian facts according to the Lamarckian evolutional hypothesis of Species, which Geoffroy had adopted in the following terms: "La formation successive et leur évolution dans le cours des âges." He then proceeds:—"Je montrerai des formes remplacées insensiblement par d'autres, qui n'auraient pu s'accommoder de l'ancien ordre des choses;" in other words, the battle of life was against them.

Reflecting on the Palæontologist who guided his course in the science, "*par de faits positifs*,"[1] Geoffroy affirms, "qu'il renonce à ce qu'il y a de plus vif, de plus enivrant, et de plus profondément philosophique dans la vie des sciences."[2]

"Les modifications insensibles d'un siècle à un autre finissent par s'ajouter et se réunissent en une somme quelconque. Si ces modifications amènent des effets nuisables, les animaux qui les éprouvent cessent d'exister, pour être remplacés par d'autres, avec des formes un peu changées, et changées à la convenance des circonstances." See also the 'Section' entitled 'Le degré d'influence du Monde ambiant pour modifier les formes animales,' 4ème Mémoire, p. 79.

Under this conviction Geoffroy rejoiced to see the transitional step, though short, which the extinct oolitic Crocodile, of "Quilly," his *Steneosaurus*, made toward the modern Gavial. Still more exultant would have been his reception of the form here described of an advance made in a secondary formation, nearer our times, beyond the gangetic long-beaked Crocodile to the shorter and broader cranial characters of the more numerous and widely distributed "Emydosaurians," representing the existing genera *Crocodilus* and *Alligator*.

[1] 'Divers Memoires,' &c., p. 137. [2] Ib., ib.

CHAPTER V. Order—SAUROPTERYGIA, *Owen*.

Genus—Pliosaurus, *Owen*.

In the genus of *Sauropterygia* called *Plesiosaurus* (*ante*, p. 1) the cervical vertebræ exceed in number and the neck in length those of other Saurian genera, and the skull, so supported, is small in proportion. But, among the species defined and described in the present volume (pp. 1—34), a certain range of variety is exemplified in these respects. In *Plesiosaurus homalospondylus*, for example (pp. 12—20, Tab. V), the cervical vertebræ are thirty-eight in number, and together include seven lengths of the skull. In *Plesiosaurus rostratus* (pp. 20—33, Tab. IX) the same vertebræ are but twenty-four in number, and together equal only one and a half the length of the skull they support.

The direction of specific modification here indicated gave warning of the secondary importance of the cervical character, and at the same time suggested a possibility of a still larger head with concomitantly shorter neck having been engrafted on an essentially sauropterygian type of structure.[1]

The discovery of certain fossil teeth which combined sauropterygian characters with modified shape, and a size much exceeding that of any of those in the then known *Plesiosauri*, led me to make them known as indicative of a distinct genus under the name *Pliosaurus*.[2]

These teeth (*Sauropterygia*, Pl. 33, vol. iv) have a crown thicker in proportion to their length and three-sided in shape, showing a subtriedral transverse section, with one side flattened (ib., fig. 3), and bounded by prominent ridges from the more convex sides, which are rounded off into each other, and alone show the well-defined longitudinal ridges of the enamel (ib., figs. 1 and 2).

The cervical vertebræ (*Sauropterygia*, Pl. 18) are so compressed from before backward (fig. 1) as to approach the ichthyosaurian type (pp. 45, 85, Tab. xvii, xxix), but the articular surfaces are almost flat, (fig. 2); and though I have found as many as twelve in one individual, they are so compressed as to cause a very short neck to intervene between a large head and a massive trunk, in which the dorsal vertebræ resume the ordinary plesiosaurian proportions.

[1] See "Remarks on this subject," in connection with a proposed Order called *Macrotrachelen*, by v. Meyer, in my 'Palæontology,' 8vo, 1851, pp. 252, 253.

[2] 'Report on British Fossil Reptilia,' Part ii, 1841, in "Reports of the British Association for the Advancement of Science" for that year.

A cervical vertebra (*Sauropterygia*, Pl. 18) of a *Pliosaurus*, from the Kimmeridge Clay of Foxcombe Hill, near Oxford, measures, for example, in breadth six inches; in depth, or vertical diameter, five inches; while in length, or the diameter corresponding with the axis of the animal's body, or of its vertebral column, it measures only two inches and a half. Nevertheless, with these ichthyosaurian proportions is associated an essentially plesiosaurian type of structure. The lower surface of the cervical centrum (ib., fig. 2) shows the pair of vascular foramina; the terminal articular surfaces are flat or very slightly concave: the cervical rib was ligamentously tied, in some species, to two processes, the di- and parapophyses (fig. 1), occupying two thirds of the fore-and-aft extent of the side of the centrum, slightly projecting beyond the surface, and divided by a deep linear fissure. I have rarely seen an instance in which the neurapophyses were anchylosed to the centrum, and never one with the pleurapophyses so attached. At the trunk end of the series the costal processes begin to climb, as in *Plesiosaurus*, upon the neurapophyses,—the diapophysis growing at the expense of the parapophysis, until the rib becomes supported, in the dorsal region, upon a single strong and prominent process: this is subdepressed, with an oval transverse section, which is rather sharp at the anterior margin. The vertebral centrums begin to gain in length as the costal processes rise in position, and those of the dorsal region have attained to quite plesiosaurian proportions. Throughout the rest of the column the vertebræ closely repeat the plesiosaurian characters on a large scale. The sides, or non-articular surface of the centrum, are rugous near the articular ends, elsewhere smooth, and in the dorsal region longitudinally concave. In the caudal vertebræ the costal process is undivided, prominent, with a vertically elliptical section, continuous with the neurapophysial surface at the base of the tail: the lower surface of the centrum is square-shaped and nearly flat: its angles are marked by the hypapophysial surfaces, of which the anterior pair is usually the largest.

The generic character derived from the organs of locomotion is the apparent absence of the antibrachial and cnemial bones, which seem to be represented by a proximal row of three large "carpal" and "tarsal" ossicles. On the homology of these I shall offer remarks in the sequel.

As to the history of the present genus, I may briefly state that in a 'Report on British Fossil Reptiles,' communicated to the Meeting of the British Association for the Advancement of Sciences, held in 1839, and printed in the volume of 'Reports' for that year,[1] I described certain fossils, from which were deduced the two species of *Plesiosaurus*, called "*grandis*" (p. 83), and "*trochanterius*" (p. 85). In my second Report on the same class of fossils communicated to the Association in 1841, I pointed out (p. 60) the characters by which these two species departed

[1] 'Report of Brit. Assoc.,' 8vo, pp. 83, 86, 1839.

so far from the type-characters of *Plesiosaurus* as to merit being placed in a distinct genus or subgenus, for which I proposed the name of *Pliosaurus;* admitting at the same time in reference to the two species, that "subsequent discoveries and observations were needed to supply distinct and recognisable characters for them" —"the two forms of femora, on which they were founded, not having then been found so associated with vertebræ and other bones as to aid in their definition."[1]

I am now enabled to describe and figure specimens, among those that have subsequently come under my notice, which afford good grounds for the acceptance of the two species, and for the addition of a third to the genus *Pliosaurus.* It may seem strange that jaws which have lost all their teeth should yield new characters derivable from the number, proportions, and disposition of such organs; but herein a Palæontologist's mode of work is like that of Antiquaries of another order, who read inscriptions on Roman buildings by the nail-marks when the letters themselves have been wrenched off for the sake of the metal.

Species—*Pliosaurus grandis*, Owen (*Sauropterygia*), Plate 19, figs. 1 and 2.

PLESIOSAURUS GRANDIS, *Ow.* Report on British Fossil Reptiles, 8vo, p. 83, 1839.
PLIOSAURUS BRACHYDEIRUS, *Ow.* Odontography, 4to, p. 283 (?), 1840.

The most complete example of the skull of a Pliosaur which has come under my observation was disinterred from the Kimmeridge Clay, at Kimmeridge, Dorsetshire, under the superintendence of J. C. Mansel-Pleydell, Esq., F.G.S., of Longthorns, in that county. This skull is also the largest of such specimens hitherto found; and, since the matrix has been removed, it has yielded the most instructive characters of cranial structure and dentition. Originally sent to me with the skull of *Plesiosuchus* (p. 147, pl. 20) for determination and description, both specimens have since been presented by their discoverer to the British Museum. The same liberal donor has subsequently enriched the National Collection by a lower jaw and part of the cranium, with evidence of the locomotive organs of the *Pliosaurus trochanterius.* I shall premise to the descriptions some of the dimensions of remains of both specimens.

[1] Ib. (Second Report), p. 54, 1841.

TABLE OF ADMEASUREMENTS.

	Pliosaurus grandis.			*Pliosaurus trochanterius.*		
	Feet.	Inches.	Lines.	Feet.	Inches.	Lines.
Length of the mandible in a straight line from the fore end of the symphysis to the angle of the jaw .	5	8	—	4	4	—
Ib., following the curve on the outer side of the ramus .	5	11	—	4	5	6
Length of the alveolar series following the curve .	3	7	—	1	9	6
Length of the "symphysis mandibulæ" . .	1	1	6	1	4	6
Greatest breadth of ditto	—	7	3	—	7	4
Breadth at posterior part of ditto . . .	—	6	9	—	7	4
Depth of, at the same part	—	5	6	—	3	9
Depth of ramus anterior to articular surface . .	—	4	3	—	4	9
Breadth of mandible at the hind end of the alveolar series	1	11	—	—	8	8
Length of cranium from the occipital condyle to the end of muzzle[1]	4	9	—	—	—	—
Greatest breadth of premaxillaries, viz. across the fourth pair of alveoli	—	6	9	—	—	—
Breadth behind the fifth pair of alveoli . .	—	5	6	—	—	—
Breadth of cranium behind the alveolar series . .	2	1	—	—	—	—
Length of palato-nares	—	5	—	—	—	—
Breadth of ditto	—	1	8	—	—	—
Distance from their back part to end of occipital condyle	—	6	5	—	—	—

In *Pliosaurus grandis* the number of alveoli on each side of the upper jaw is twenty-seven or twenty-eight. The first pair (Pl. 19, fig. 2) are terminal and approximate; the outlet of each measures 1 inch 3 lines in long diameter, which lies in the axis of the jaw: the second alveolus with an outlet 1 inch 9 lines in long diameter, which is transverse to the jaw's axis, is divided by a partition of 4 lines breadth from the first: the third socket is divided by a partition half an inch in breadth, from the second; its outlet is circular, and 2 inches in diameter: the fourth socket is of similar size, and at rather less distance from the third: the fifth socket is less in transverse diameter than the third, but is equal in fore-and-aft diameter to the fourth, from which it stands 9 lines apart. These five pairs of alveoli are in the premaxillary bones (22), and occupy the whole of their alveolar extent. An interval of rather more than two inches intervenes between the last premaxillary and the first maxillary alveolus, which is the sixth of the series; and this interval is traversed obliquely by the maxillo-premaxillary suture (Pl. 19, fig. 2). The maxillary alveoli have partition walls of about 4 lines in thickness at their free border; but these become thinner as the teeth decrease in size in the hinder third part of the series. The alveoli increase in size from the first to the fourth maxillary tooth (ninth of the dental series); the longest diameter of the aperture of this socket is 3 inches: thence the alveoli

gradually decrease in size to a diameter of half an inch. The form of the alveolar aperture is, for the most part, a full oval, nearly circular, with the long diameter inclining more or less transversely.

The margins of the larger maxillary alveoli are the most prominent. The entire alveolar series describes longitudinally and horizontally a gently undulated course, the premaxillary series forming a slight convexity, and the larger maxillary alveoli a similar convexity, outward. Longitudinally and vertically the alveolar border is almost straight as far as the seventeenth tooth, and then gently bends upwards to the hind end of the series. A groove, deepening into fossæ answering in number to the alveoli, extends along the inner side of each premaxillary series. This groove is interrupted at the diastema between the premaxillary and maxillary alveoli: it recommences at the inner side of the maxillary series, also deepening into pits opposite the inner and back part of the alveoli, and continues, though feebly indicated, along the hinder third of the alveolar series.

The bony palate is entire, save at the palato-nares (ib., fig. 2, *r*, *r*); but on the inner side of the twelfth socket, counting backward, on each side, there is a nervo-vascular foramen terminating a canal in the upper jaw, directed obliquely downward and forward: the foramen is elliptical, an inch in diameter; a shallow channel extends a few inches in advance of its outlet, and three or four similar but smaller foramina succeed each other anteriorly near the inner wall of the internal alveolar groove, leading to a linear channel 7 inches long, which, with its fellow on the opposite side, defines the base of a median longitudinal ridge of the bony palate between the first three pairs of maxillary alveoli, which ridge is transversely convex, and about an inch in breadth. As the bony palate expands in breadth, behind the nervo-vascular foramina, it presents transversely a broader median convexity, bounded by lateral shallow concavities. On the transverse line, between the sixteenth pair of alveoli, are the anterior ends of the palatine bones, which are divided by a median suture (20, 20). The major part of the palato-nares are bounded by the pterygoids (24, 24), which extend backward to the base of the occipital condyle, underlapping the basi-sphenoid and basi-occipital, developing ridges which project below the level of the lateral parts of the fossa, and converging to meet behind the area, including the posterior nostrils. External to these ridges the pterygoids diverge to abut against the tympanic pedicles.[1] The mesial border of an ectopterygoid is preserved at 25, fig. 1.

The number of alveoli in each ramus of the mandible (Pl. 19, fig. 1) is twenty-five or twenty-six. The five alveoli corresponding with the premaxillary sockets in the upper jaw are the largest. They are separated by similar intervals.

[1] The tympanic articulations of the lower jaw, which extend the cranium beyond the condyle, are broken off.

Between the fifth and the sixth alveolus is a diastema of about 8 lines; the long diameter of the sixth alveolus is 1 inch 10 lines. An interval of 5 lines divides it from the seventh socket. The succeeding ones are closer together: they gradually increase in size to the twelfth or thirteenth, but do not obtain the size of those opposed to them above; they then gradually decrease in size and depth to a diameter of about half an inch.

The summits of crowns of successional teeth protrude from fossæ at the inner and back part of the anterior alveoli. The crown of a more advanced successional tooth projects into the bottom of the socket of the third and fifth of the symphysial series: these teeth show the characters of the genus *Pliosaurus*.

The inter-alveolar part of the "symphysis mandibulæ" forms a median longitudinal rising, less convex or ridge-like than the one on the palate above. Fossæ are discernible on the inner side of the mandibular alveoli, but less marked in the upper jaw. The apex of a successional tooth appears in two of these pits. On the inner side of the posterior third of the mandibular ramus there is a wide and deep channel between the surangular (29) and angular (30) elements; and this groove is continued forward indicative of the upper border of the splenial (31) which extends along the inner side of the lower half of the dentary nearly to the symphysis. The articular surface of the mandible (29), 7 inches is transverse, and 5 inches in antero-posterior extent, is slightly concave transversely at the inner three fourths of its extent, and then gently convex at the outer fourth; it is more concave from before backwards in the major part of its extent, but the peripheral boundary is not entire.

The sauropterygian affinities, as contradistinguished from the ichthypterygian, are exemplified in the more complete and separate sockets of all the teeth, and in the smaller proportion contributed by the premaxillaries to their support and to the formation of the upper jaw.

The palato-nares of *Pliosaurus* are more linear and approximate than in the species of *Plesiosaurus* (*Pl. Hawkinsii*, Pl. XVI; and *Pl. rostratus*, Pl. XIII, *r*, *r*), in which they have been observed.

Species—*Pliosaurus brachydeirus*, Owen.

In the Museum of Geology at Oxford are considerable proportions of the upper and lower jaws of a *Pliosaurus* from the Kimmeridge Clay at Market-Raisin.[1] The teeth, in proportions and arrangement, correspond so closely with those in the specimen above described as induced me to surmise that they might belong to the same species. The following are the differences which I have noted between

[1] 'Second Report on British Fossil Reptiles,' "Report of British Association," p. 61, 1841.

them: the widest diastema divides the fourth upper tooth from the fifth in the Oxford specimen, not the fifth from the sixth: the maxillo-premaxillary suture with the lateral compression at this interval, is as in the British Museum specimen. If the pair of small anterior sockets and teeth are wanting, either through age or accident, in the Oxford specimen the difference noted would be accounted for. It may be remarked that the number of alveoli—twenty-six—on the least imperfect side of the upper jaw is the same in both skulls, and in both a small part of the series is wanting posteriorly. In both the premaxillary part of the jaw containing four pairs of large teeth is slightly expanded. In the maxillary part of the Oxford specimen the teeth increase in size to the sixth; in the British Museum specimen to the fifth; beyond which they gradually diminish. The length of the best-preserved alveolar series is 3 feet in the Oxford specimen, and 3 feet 7 inches in that in the British Museum.

In the mandible from Market-Raisin there are thirty-five sockets in each side; in that from Kimmeridge there are only twenty; but as neither specimens have the alveolar series quite complete, I do not feel that there is sufficient ground to reject the hypothesis of individual variety. In all the essential characters, including length of symphysis mandibulæ, the Market-Raisin skull agrees with that in the Kimmeridge example of *Pliosaurus grandis*, and differs from that of *Pliosaurus trochanterius*, next to be described. If, however, the minor differences which have been noted between the Oxford specimen and that figured in Pl. 19, figs. 1 and 2, should prove to be constant, the specific name "*brachydeirus*," by which I originally indicated Dr. Buckland's magnificent specimen[1] from Market-Raisin, might be retained for it.

Species—*Pliosaurus trochanterius*, Owen (*Sauropterygia*) Plate 19, figs. 3, 4, 5.

PLESIOSAURUS TROCHANTERIUS, *Ow.* Report on British Fossil Reptiles, 8vo, p. 85, 1839.

In the work above cited the specific character of the fossil Reptile in question was indicated by modifications of the femur; but the chief distinction between *Pliosaurus trochanterius* and *Pl. grandis* is conspicuous in the greater relative extent of the symphysis mandibulæ in the former, and in the greater proportion of the dental series lodged in that part of the lower jaw. This character is exemplified in the fourth admeasurement in the "Table," p. 156, and in Pl. 19, fig. 4, as compared with Pl. 19, fig. 1.

The surangular developes in *Pliosaurus trochanterius* [fig. 29′] a low but well-

[1] 'Odontography,' p. 283.

marked angular coronoid process. Anterior to this the upper border of the mandible becomes thick and transversely convex; and, an inch below the border, the outer side of the ramus is impressed by a wide and deep longitudinal groove. So much of the articular surface as is preserved agrees in structure and form with that in *Pliosaurus grandis;* and the extent of the angular projection behind the articular cavity to the same.

The fore part of the symphysis, including the first three pairs of teeth, restored in Pl. 19, fig. 4, has been subject to such violent horizontal force as to be crushed in that direction, and broken across both the upper and the under surfaces of the rest of the mandible, without having been detached from the intervening structure or tissue of the bone. The bottoms of the sockets only of the included teeth are preserved, with parts of the partitions which, here, are only from 2 to 3 lines thick. These sockets increase in size to the third. The diameter of the outlet of the fifth socket, which is the first entire one, measures 1 inch 9 lines across; it is rather less longitudinally. The outlets of most of the alveoli are subcircular, with a tendency to a subquadrate section, with intervals not exceeding 2 lines, and they retain a uniformity of size to within four or five sockets at the end of the series, which progressively decrease in size.

The total number of teeth, as shown by sockets, in each mandibular ramus, is fourteen; of which ten occupy the symphysial part of the jaw.

The upper surface of the symphysis between the first six teeth is flush with the alveolar outlets, is smooth, and slightly convex transversely. Beyond the sixth pair of teeth the intervening surface rises above the inner borders of the alveoli as high as half an inch between the ninth—eleventh pairs of sockets; the upper surface of the hinder part of the symphysis becomes slightly convex transversely, and the pointed anterior ends of the splenials (31) enter into its composition.

No part of the upper jaws of this skull of *Pliosaurus trochanterius* has been preserved; but the quarrymen extracted the hind part of the cranium (Pl. 19, fig. 6). It shows a hemispheroid condyle (1) 2 inches 8 lines in basal diameter. The foramen magnum is a full transverse ellipse, 1 inch 3 lines across. The broad and low occipital surface includes the thick horizontal backwardly projecting paroccipital ridges (4), below which extend still more backward and somewhat downward the short and broad tympanics, terminated each by a condyle convex in its outer two thirds, concave transversely at the inner third: the breadth of this condyle (28) is 5 inches.

The upper transverse ridge of the occiput is broken away. The parietal region (7) is formed by a lofty median vertical wall of bone, slightly expanding below to form the side walls of a miserably small cerebral cavity.

I have neither respect nor inclination for undue multiplication of genera; but the degree of difference in the number of mandibular teeth and extent of the

symphysis tempts to a view of the present evidence of *Pliosaurus trochanterius* as testifying to something more than specific distinction from the *Pliosaurus grandis*.

This species retains more similarity with the type Sauropterygians (*Pl. dolichodeirus*, e.g.) in the proportions of the symphysis and of the number of symphysially located teeth. Nevertheless, modifications in these particulars are presented, though in a minor degree, by species of true *Plesiosauri* [compare Pl. 3, fig. 2 (*Plesiosaurus dolichoderius*), with Pl. 16, fig. 2 (*Plesiosaurus Hawkinsii*)].

A specimen subsequently submitted to me, includes the part of the maxillary bones, with eight or nine pairs of alveoli at or very near to the hind end of the series, of a smaller individual of the *Pliosaurus trochanterius* than that to which the lower jaw, Pl. 19, fig. 4, belongs.

This fragment measures 11 inches in length and 6 inches in greatest breadth. It is from the same locality and formation as the larger skull, viz. the Kimmeridge Clay of Kimmeridge. Both specimens have been liberally presented to the British Museum by the discoverer, J. C. Mansel-Pleydell, Esq., F.G.S.

Teeth.—Of the teeth showing the generic modification above defined (p. 152) the best specimen is the subject of Plate 33. It was found in a deposit of Kimmeridge Clay, near Oxford, where fragmentary specimens had been obtained similarly testifying to the bulk and power of some old tyrant of the later Oolitic seas. In one of these specimens, the subject of Pl. 19, fig. 7, the circumference of the base of the crown measures 7 inches 6 lines, equalling that of a full-sized tooth of a cachalot-whale (*Physeter macrocephalus*). Of the enamelled crown three inches are preserved and about as much of the cement-covered base, the longest diameter of which is 2 inches 2 lines; that of the fractured end of the crown is 1 inch 3 lines. The length of an entire tooth is shown in Plate 33; the fractured part of the base exposes a pulp-cavity (fig. 2, *c*) of about 2 inches diameter, with a hard dentinal wall of from 4 to 6 lines in thickness, which gradually decreases to the broken or implanted basal ends of the tooth. The fractured part of the crown (fig. 2) exposes a solid and compact mass of dentine. The generic characters of the tooth are boldly pronounced. The smooth facet, defined by strong marginal ridges (fig. 3), shows a few narrower ones, encroaching upon the basal part, where the enamel gives way to the coat of cement covering the long and strong root of the tooth. This is about thrice the length of the crown, and testifies to the strength of implantation. The two sides of the crown (figs. 1 and 2) are continued into each other by an uninterrupted curve; the ridged enamel angles between these facets and the outer smoother convex side of the tooth are well defined. The terms "convex" and "concave" refer to the longitudinal direction of the tooth; all the sides are convex across, the outer one being the least so. The unridged surface of the enamel is finely wrinkled by

short wavy risings, frequently joining or reticulate, rather affecting the longitudinal course. The same character is presented by the enamel covering the contiguous parts of the other sides of the tooth, and extends furthest in that represented in fig. 1, Plate 33. The enamel, which is a mere film at the base of the crown, gains thickness towards the apex; its adhesion to the dentine is helped by numerous fine, wavy, longitudinal, sub-equidistant, linear risings on the surface of that substance. The slight outer convexity is uniform; the inner curve is wavy, passing from the slight concavity at the crown to a slight convexity at the junction of crown and fang, then again becoming slightly concave.

The subject of Plate 33, now in the British Museum of Natural History, was presented to the Trustees by the Hon. Robert Marsham, F.G.S. This tooth exemplifies its complete state of formation, the entire fang has been developed, and the unworn crown shows that the time had not arrived for the absorption of the root through pressure of a successional tooth, which undermining process is usually concomitant with the loss of efficiency of the dental instrument through the wear of the crown. It accordingly presents a total length of one foot, a third of which is formed by the crown, the rest by the root. This cement-covered part expands for the coronal half of its extent to a diameter of 3 inches, which is the thickest part of the tooth; it then gradually contracts to the thin borders of the base of the pulp-cavity, where probably an additional inch of the tooth has been broken away.

In excuse for the foregoing details, which may be deemed tedious, I plead the rarity of a specimen so complete as to yield the collective dental characters, and the frequency of fragments, of which any one showing part of the enamelled surface of the tooth may now have the nature of its markings and its position in the tooth-crown recognised; thus it may throw light on the mesozoic bed, which is characterised by the present Sauropterygian genus.

Finally, I may refer to the evidence of provision, in *Pliosaurus*, for a worn or broken lethal weapon, by a successional tooth; and this provision, common to Reptilia, relates to the lengthened period during which the individual depends upon its teeth for sustenance.

In size, in general shape, in uniformity of character throughout the mandibular series of teeth, the existing Cachalots most resemble the Pliosaurs. Those whales are also deemed to be naturally long lived, but their term of life must depend on their enjoyment of the organs by which they get their food, and there is no evidence of the first fully-developed series of teeth ever being replaced by a second set. The cachalots were not favoured with the mode of supply for lengthened individual life which is exemplified in modern as in the ancient aquatic Saurians.

For how many years the individual Pliosaur dominated its latitudes and preyed upon marine contemporaries we may not be able to determine, but its dental

character indicates that its life period far exceeded that of the toothed whale of similar bulk.

For how many centuries—generation after generation—the great Pliosaurs carried on their predatory wars some feeble conception is afforded by geological inferences from the gradual formation and accumulation of the ocean-beds which have received the dead bodies, and have now revealed to us the insoluble and petrifiable parts of the carcases of those cold-blooded carnivores.

Sterno-coraco-scapular frame (*Sauropterygia*, Plate 20).—This characteristic part of the skeleton in *Sauropterygia* being incompletely preserved in that of *Plesiosaurus dolichodeirus* (*Sauropterygia*, Plate 1), its description has been deferred to the present section, when the perfect condition of the part, subsequently worked out in another example of the same species (ib., fig. 1), serves to exemplify the modifications of the same part in the genus *Pliosaurus*.

In both genera of their order the place and function of a sternum are mainly fulfilled by the pair of coracoids (52, 52) which meet by a longitudinally extended suture (*s, s*) below the thoracic part of the abdominal cavity. Behind this mesial suture the coracoids diverge and terminate freely by a broad margin, each with an angle inclining laterad (52′, 52′). Anteriorly the sutural portions slightly diverge, and expose the end (59′) of the mesial plate representing an "episternum;" laterally each coracoid contracts in length, becomes thickened, and presents two roughened articular surfaces; the hinder one (*h′*) contributes the corresponding portion of the articular cavity for the humerus, the fore one (*ch*) joins the scapula (51) by the suture laterad of which the scapula contributes the free portion (*h*) of the glenoid cavity.

In *Plesiosaurus* (fig. 1) the hinder end of the scapula, which is the thickest part of the bone, is thus divided pretty equally between its coracoidal (*ch*) and humeral (*h*) articular surfaces; both are rough or "syndesmosal," the latter least so. In advance of the surfaces (*h, ch*) the scapula thins and contracts chiefly by a strong margino-mesial concavity contributing the outer border of the "coraco-scapular vacuity" (*c s*). The outer, thicker border of the scapula, in *Plesiosaurus*, (fig. 1) is straight, and the bone extending forward expands to unite with the episternum (59) by the suture (*sh*).

The episternum (59) presents anteriorly a mesial notch, from each angle of which a thicker border extends outward and backward to its sutural union (*s h*) with the fore end of the scapula. At this union the episternum contracts and is continued backward to join the coracoids, passing a short way internal to them, and appearing externally as a pointed end of the bone at the fore part of the narrow mesial interspace of the coracoids, which interspace interrupts, anteriorly, their extensive mesial sutural union, *s, s*.

Thus the sterno-coraco-scapular frame presents an anterior and a posterior notch and a pair of subcircular vacuities. The above-defined characters of this

portion of the skeleton, save that of the scapular element, are common to both the genera of the *Sauropterygia.*

The chief and suggestive modification of the mass in the Pliosaurian genus is the retention of a typical character of the scapula which is lost in *Plesiosaurus*, the production, namely, of the part of the blade-bone (Pl. 20, fig. 2, 51 x) laterad and dorsad, where it terminates freely. This portion represents the main body of the scapula in higher vertebrates; but, as in the allantoic or abranchiate group,[1] (*Reptilia*, *Aves*) without expanding. The portion of the scapula common to both the present extinct genera, which contributes its share (*h*) to the glenoid cavity, is separated, in *Pliosaurus*, from the free portion (51 *x*) by the notch (*n*). In advance of this the Pliosaurian differs from the Plesiosaurian scapula by its greater relative breadth, extending its sutural border (*sh*) mesiad so as to touch or join the fore end of the coracoid (*sc*).

The coracoids retain their large proportional size, but have a less even or flattened outer surface; mesially they bulge to their common suture (*s*, *s*), giving more room to the ventral cavity; and, at the transverse parallel with the borders, which they contribute to the vacuities (*c s*, *c s*), they bend dorsad, or inward, suddenly contract (*sc*); but contribute, as in *Plesiosaurus*, the mesial border of those vacuities, and articulate, underlapping it, with the hinder end of the episternum (59′).

In thus determining the homologies of the constituents of the complex bony buckler in *Sauropterygia*, I have exhausted every subject of comparison at my command in other Reptilian forms, both fossil and recent. The degree in which the abdominal surface is defended by bone in *Sauropterygia* resembles that in *Chelonia*. But, as I have elsewhere[2] shown, by dermal ossifications chiefly, these not answering to the endoskeletal elements which have been modified to that end in the subjects of the present section.

PLIOSAURUS PORTLANDICUS, *Owen*. *Sauropterygia*, Pl. 19, fig. 8.

The generic distinction from *Plesiosaurus*, indicated by the term *Pliosaurus*, and originally suggested by characters of the teeth and the cervical vertebræ, is further confirmed by the structure of the bony framework of the paddles. The modification in question, like the fore-and-aft compression or shortness of the cervical centrums, exemplifies the nearer resemblance, I will not say affinity, of *Pliosaurus* to *Ichthyosaurus*; the segment of the natatory limb which answers to the anti-

[1] 'Anatomy of Vertebrates,' vol. i, 1866, pp. 6, 7.

[2] 'Philosophical Transactions' for 1849, "On the Development and Homologies of the Carapace and Plastron of the Chelonia.

brachium and the cnemion in the higher Vertebrates, being scarcely more marked or differentiated in the present genus of huge *Sauropterygia* than in *Ichthyopterygia*.

The first indication of the modification in question was given by a specimen in which only the proximal halves of the two bones, or two chief bones, succeeding the femur were preserved along with that bone.

The inference which I drew from close inspection and comparison of the preserved portions of the two cnemial bones was subsequently confirmed or strengthened by the condition of the same segment of the fin-bones in the instructive specimen of those bones restored by Mr. Mansel-Pleydell, probably from the bones of the skeleton of the *Pliosaurus grandis* to which the above described skull belonged, and of which fin-bones a cast is exhibited in the Palæontological Gallery of the British Museum of Natural History.

Nevertheless, with the close general affinities illustrated by most of the framework and dentition of *Plio-* to *Plesio-saurus*, I waited in hopes of an opportunity of acquiring certainty as to the structure of the middle segments of the limb before committing myself to a publication of what I am now able to positively state to be a generic character of *Pliosaurus*.

The wished-for evidence reached me in the form of a block of Portland stone, in which were embedded the femur, cnemion, tarsus, and part of the metatarsus and digits of a right hind-limb, referable, by the character about to be described, to the genus *Pliosaurus*. The specimen, moreover, had the additional interest of being the first evidence of that genus from the Upper Oolite of Portland Island. It is figured rather less than one-fourth the natural size in *Sauropterygia*, Pl. 19, fig. 8.

The femur (ib., 65) presents the usual plesiosauroid proportions and characters, the pliosaurian affinity being faintly indicated, as usual, by the greater extent of the tract external to the fibular division (above 67) of the distal articular extremity. The tuberosity and contiguous rough surfaces for the attachment of muscles, at and near to the proximal end, are also a little more strongly marked, as in the *Pliosaurus grandis*, but the tuberosity is less distinctly prominent than in *Pliosaurus trochanterius*. The head of the femur, subconvex and oblong, is slightly nipped in, as it were, near its outer third part from side to side; the long axis of this surface is at right angles to the plane of the expanded and compressed distal end of the bone. A few of the crateriform elevations on the rough articular surface are preserved. The inner side of the bone is exposed in the block of matrix. The roughness for ligamentous or tendinal attachment ceases about one third of the way down the shaft. This part, gradually contracting, assumes first a circular transverse section, then becomes compressed from without inwards instead of from side to side, increasing in breadth and diminishing in thickness to the distal articular end. The surfaces for tibia (66) and fibula (67) are indicated by, or meet at, a widely open angle. The projecting part of the femur beyond the tibial surface is rounded off; that beyond the fibula is, as above remarked, of greater

extent, and may have terminated more angularly, but the extreme end has been broken away. The representatives of tibia and fibula appear in size and shape, as in *Ichthyosaurus*, to be a first series of tarsal ossicles; they, however, markedly exceed in size the ossicles of the two succeeding rows, properly constituting the tarsal segment of the fin. The bone (66) answering to the tibia in *Plesiosaurus* (Pl. 23, fig. 4, (66)) is an irregular oval or oblong flat plate, the margin adapted to the femur being longest and least convex. The breadth of this bone exceeds its length, and the inner or tibial, and the outer or fibular, margins are rounded or strongly convex; the distal margin is more even or straight at its middle part. The length of the bone (in the axis of the femur) is 2 inches; the breadth of the bone is 2 inches 9 lines: an interval of 5 lines between it and the femur indicates most probably the thickness of ligamentous matter which dissolved away after the carcase of the Reptile had sunk into the fine sand or sandy mud now hardened into Portland stone.

The fibula (67) is less, transversely, than the tibia: the margin towards the femur is almost straight; the outer and inner margins convex; the distal one is produced into a low rounded angle opposite the interspace between the tarsal bones *a* and *cl'*, and this slight modification is interesting because the homologous bone in *Plesiosaurus* (fig. 4, 67) shows a similar angular production between the same tarsal ossicles, whilst the distal end of the tibia is truncate.

Another character which would seem to show that a tarsal structure or arrangement immediately followed the femur is evidenced by a depression in the matrix indicative of a third bone, smaller than either fibula or tibia, and of an oval form with the long axis parallel with that of the fin and the small end of the oval produced towards the femur. This ossicle I regard as the homologue of the fabella (67'), which is present in some *Plesiosauri* (*Pl. rugosus*, for example, fig. 4, 67'), where its homotype in the fore-limb is represented by a detached olecranal process of the ulna. But the bone (67') in *Pliosaurus portlandicus* is relatively larger and less triangular in shape than in *Plesiosaurus rugosus*.

The thickness of these tarsal-like representatives of tibia and fibula is about 4 lines.

The three bones of the proximal tarsal row are more uniform in size and shape than in most *Plesiosauri*, the innermost or scaphoid (*s*) is, however, the smallest: it is transversely elliptical in shape, 1 inch 9 lines in breadth, 1 inch 2 lines in length; the original ligamentous interspace between it and the tibia is 3 lines. The astragalus (*a*) has a produced part of its proximal margin directed toward the interspace between the tibia and fibula: this modification somewhat interferes with the regularity of its elliptical contour. Its length is 1 inch 4 lines; its breadth 1 inch 11 lines. The interspace between it and the scaphoid is reduced to 2 lines; that between it and the cnemial bones is from 4 to 5 lines. The calcaneum (*cl*) is the largest of this row; its proximal margin is straight and parallel.

CHAPTER VI. Order—DINOSAURIA, *Owen.*

Genus—Megalosaurus, *Buckland.*[1]

Species—*Megalosaurus Bucklandi* (Dinosauria, Plate 87).

At the date of the printing of vol. i, pp. 329—354, no other parts of the skull of the *Megalosaurus Bucklandi* had been discovered or determined save the portion of the dentary element of the lower jaw, with teeth (now in the Geological Museum at Oxford), on which Dr. Buckland, in 1824, founded the genus and species; and a second mandibular specimen, from the same formation and locality, obtained, in 1851, by the Duke of Marlborough, and of which, by His Grace's permission, a description (pp. 348—351) and Plate 34, (vol. i) were taken. I was also able to extend the range of the great carnivorous Saurian by detached teeth, kindly transmitted to me, from the "Corn-brash" of Oxfordshire, to the "Bath Oolite" of Somersetshire, and the "Wealden" of Sussex (vol. cit., p. 351). Results of a study of these specimens are recorded in pp. 348—351.

Some years later, 1868, two portions of an upper jaw were obtained by Professor Phillips, F.R.S., on which he founded the restoration of the skull of *Megalosaurus*, given in, Diagram lvii, of his 'Geology of Oxford.[2]'

In 1882 additional cranial and dental evidences of Buckland's genus and species were obtained by Edward Cleminshaw, Esq., M.A., F.G.S., from the "Freestone" of the Inferior Oolite, near Sherborne, Dorset.[3]

Blocks of this stone were in course of preparation for a building, when indications of imbedded fossils being detected by Mr. Cleminshaw on fractured surfaces of the quarry-stones, he withdrew all such from the building-yard and transmitted them to the British Museum for identification.

Further requisite development of these remains having been there carried out, the following descriptions and drawings, the subjects of *Dinosauria*, Pl. 87, were taken.

In the section devoted to the genus *Megalosaurus*, in vol. i, pp. 339—354 of

[1] Buckland (Rev. Wm., F.R.S., G.S.), "Notice in the Megalosaurus," &c., in 'Transactions of the Geological Society of London,' 4to, 2nd Series, vol. i, 1824, pp. 390—396, plates xl—xliv.

[2] 8vo, 1871, p. 199. The same specimen is the subject of a paper by Professor Huxley, F.R.S., in vol. xxv of the 'Quarterly Journal of the Geological Society of London.'

[3] 'Dorset County Chronicle,' June 15th, 1882; "Report of a Meeting of the Dorset Natural History and Antiquarian Field Club."

the present work, the materials for a reconstruction of the skull were limited to portions of the mandible and divers teeth therein implanted or detached.

The differences shown by the mandibular specimens were limited to size, the vertical diameter of the deepest part of the type mandible being $3\frac{1}{2}$ inches, while that of the Blenheim specimen gave $4\frac{1}{2}$ inches. But as the teeth, retained in these mandibular pieces, were of the same size, as well as form and structure, there was no ground for predicating distinction of species.

In the Blenheim specimen I was permitted to expose the germs and portions of the successional teeth concealed in the substance of the mandible.

Before entering on the description of the first of the present series of fossils which demonstrates cranial characters not hitherto determined, I may premise that existing Saurians show differences in the degree of ossification of the outer wall of the facial part of the skull.

In *Crocodilia* it is entire from the relatively small orbit behind to the smaller single nostril in front; and there is no break in that wall, in modern and Tertiary species, answering to the antorbital vacuity in Liassic genera; but this opening, recalling the antorbital nostril of *Ichthyosaurus*, is very small and is margined by the maxillary, lacrymal and nasal bones.

In existing Lacertians much difference is seen in this character, but in none is the face so completely ossified as in the Crocodiles. The Monitors (*Thorictes*, *Tupinambis*) come nearest thereto, the nostril being divided from the orbit by a broad triangular facial plate of the maxillary, supplemented behind by a narrow malo-lacrymal one. In *Lacerta* the lacrymal enters in larger proportion into the formation of this part of the bony face, and the external nostrils are relatively wider. In *Iguana* the facial wall dividing the nostril from the orbit is relatively narrower, and the apex of the maxillary process is further removed by a large interposed lacrymal from the nasal bone. But in the Lacertians with a carnivorous dentition (*Hydrosaurus*, *Varanus*) the outer bony nostrils are remarkable for their great relative size, especially length; and the maxillary sends upward and backward a long but narrow pointed plate, which, in *Varanus bivittatus*, crosses in front of a small lacrymal bone to articulate with the prefrontal.

Here we attain the cranial modification which forms the best guide to the interpretation of the appearances presented by the fossil, the subject of Plate 87, fig. 1, and restored on a Varanian type in the figure 5.

But, before entering on this comparative survey, I may note the corresponding degree of resemblance which the skull of *Iguanodon* presents to the herbivorous and mixed-feeding Lacertians, *Iguana* and *Thorictes*, with correspondingly adaptive shapes of the teeth. In the relative size of the external nostril *Iguanodon Foxii* resembles more *Tupinambis* than it does *Iguana* with the larger nostril; and the side-wall between nostril and orbit is relatively broader and more extensive in *Iguana*

than in either of the blunt- or thick-toothed Lacertians. I may remark, also, that, as usual in the larger forms, the orbits are relatively smaller than in the dwarfed kinds.

In all the Lacertians here compared, teeth are developed from the whole (*Iguana*, *Tupinambis*), or nearly the whole (*Hydrosaurus*, *Varanus*), of the alveolar border of the maxillary; consequently this dental series extends beneath both nasal and orbital vacuities, but for a less extent in the carnivorous than in the herbivorous Lacertians. *Scelidosaurus*, in the degree and kind of its facial ossification, repeats the mammalian character exemplified in *Iguanodon*.

Of the subjects of the present paper the first block of Lower Oolitic Freestone includes a great proportion of the right side of the facial part of the skull (Plate 87, fig. 1). The missing parts are the fore end of the premaxillary (ib. 22′) and the hind or suborbital end of the maxillary (21′); the upper and hinder pointed termination of the facial process of the maxillary is preserved in articulation with the prefrontal, *f*.

The length of this facial fossil is 1 foot $3\frac{1}{4}$ inches; its height from the upper angle (*a*) of the maxillary process to the tip of the longest subjacent tooth, *in sitû*, is 9 inches.

Of the premaxillary are preserved part of the nasal process (22″) and so much of the alveolar part (22) as lodges two fully developed and protruded teeth and the sockets of two others: an intervening part of the bone has been chiselled away to admit a wedge for the quarrying-operations; the length of the preserved premaxillary nasal process (22″) is 4 inches, the breadth of its base is 1 inch: it narrows to its apex, being limited to the fore and under part of the large bony narial vacuity (*n*, *f*) in the present specimen.

So much of 22″ as is preserved forms rather more than one third of the lower border of the external nostril, the rest of that border with the hinder boundary (*a*) being contributed by the maxillary (21, *a*). The suture between these bones is distinct.

The preserved length of the alveolar part of the maxillary (21, 21′) is one foot: the upper border of this part contributes to the large narial (*n*) and in a less degree to the orbital (*o*) vacuities; but these portions of such tooth-bearing part of the upper jaw combine to form the base of the facial process, which is between four and five inches in extent: its breadth, at one inch above the border line (21, 21′), is 3 inches; this breadth is nearly preserved to the angle (*a*), about six inches above the alveolar border, at which angle the maxillary is continued backward, above the fore part of the orbit, gradually narrowing to a point, which joins the prefrontal.

Much of the outer wall of the alveolar part of the maxillary adheres to the block of freestone in which the counterpart of the above-described cranial fossil is

preserved: but this counterpart shows only the impressions of the teeth, which are well preserved in the block containing the chief part of the fossil. Of these teeth four are premaxillary, the rest maxillary.

The teeth closely repeat the characters of those of previously described dental evidences of *Megalosaurus Bucklandi.*

Of the foremost preserved premaxillary tooth, 2 inches of the crown remain, with half an inch of a mutilated base: the next tooth is represented by a smaller protruded apical part of the crown. The socket of the larger intervening tooth is broken away with the implanted tooth-root, exposing the pulp-cavity. The impression of the broken and missing part of the smaller premaxillary tooth gives two inches of length to this tooth, the implanted remainder of both teeth has gone with the supporting bone. In advance of the larger premaxillary tooth is an elliptical cross-fractured basal part of a third (the anterior) tooth showing a long diameter of nearly half an inch.

Ten teeth are preserved in the maxillary bone. Between the foremost, third and fifth, are crowns of successional or undeveloped teeth. Of the foremost of these (second in the series) the apex only of the crown has appeared above its socket, the rest of the tooth is exposed by removal of the socket's outer wall: a length of enamelled crown of 2 inches 5 lines is thus shown. The length of the protruded crown of the first maxillary tooth is 1 inch 9 lines, that of the third tooth is 2 inches 3 lines, its total length is 5 inches. Of the fourth tooth the apical half-inch of the crown is protruded: the total length exposed in the quarrying is $3\frac{1}{2}$ inches. The similarly shown length of the fifth tooth is 4 inches 9 lines, that of the enamelled crown being 3 inches. The sixth tooth shows 2 inches of free enamelled crown, and $2\frac{1}{2}$ inches of the rooted cement-clad part, the latter exposed by loss of the bone. The seventh maxillary tooth is represented by a smaller proportion of the protruded crown. The eighth tooth is a functional fully developed one, but of smaller size than the third and fifth. The apical half of a somewhat smaller crown of a ninth tooth has emerged, and behind this is the indication of a fully developed tenth tooth, not larger than the eighth. I cannot predicate with confidence of an eleventh maxillary tooth. The crown of such exposed tooth on the transversely fractured surface of the block may have come from the lower jaw.

Of the maxillary teeth the four or five hinder ones are suborbital, the three front ones are subnarial; the three intermediate teeth, including those with longest and largest crowns, received the support, in biting actions, of the base of the facial process (*a*).

At the fore part of the orbital cavity are two thin osseous plates, (*e, e*) convex outwardly, of subtriangular form, with the apex naturally cut off so as to contribute half the circumference of a protruding circular space, half an inch across, exposing

the matrix; the margin of this circular aperture is slightly raised. These plates show, or have been resolved into, three lamellæ, each less than a millim. in thickness; part of one lamella, and an impression of another, is shown on the slab containing the teeth and bones; parts of three lamellæ of one of the plates adhere to the counterpart block. The matrix near what seems to be the pupillary border is stained of a darker colour than the rest. I deem it probable that we have here an indication of the eye-ball of the Megalosaur, and that the pupillary corneal part of the ball was strengthened by a few large sclerotic plates. The indicated diameter of such eye-ball is two inches. The attention devoted to this part of the fossil was requisite to determine whether it might be part of a lacrymal bone or of the sclerotic.

The orbit in its great relative size and departure from the usual circular form finds, amongst existing Saurians, the nearest approach in the large carnivorous Varanians. The comparatively small size of the eye-ball accords with the hugeness and carnivority of the extinct terrestrial Dinosaur.

An indication that the lower jaw had been inclosed, with the portion of the upper one above described, in the same mass of matrix, is given by the impression of the crown of the mandibular tooth projecting into the interval between the third and fourth maxillary teeth, in the block exposing the upper jaw, the tooth leaving that impression being preserved in the counterpart block. The extent of the mandibular tooth, so preserved, measures 1 inch 8 lines, and includes the upper two thirds of the crown; the breadth of the fracture is 8 lines, and this exposes the termination of the pulp-cavity.

I infer, therefore, that the portions of mandible with teeth next to be described are not only Megalosaurian, but formed parts of the same individual as the preceding fossil. They were worked out of separate blocks of freestone which were in contiguity prior to the masonic operations.

The first portion shows the outer side of the anterior ten inches of the right mandibular ramus, a portion of which, one third the natural size, is shown in fig. 3. The vertical diameter of the bone is $2\frac{1}{2}$ inches at 2 inches distance from the fore end, and gives $2\frac{3}{4}$ inches at the opposite fractured end. The symphysial profile is obtusely rounded or moderately convex, as shown in the left ramus (Pl. 87, fig. 2). The foremost tooth rises at half an inch therefrom. This tooth gives an exserted length of crown of $2\frac{1}{4}$ inches, with a basal breadth of 9 lines. An interval of nearly one inch divides it from the second tooth, also fully developed, but with the apical half of the crown broken away. The third, fourth, and fifth mandibular teeth rise at similar intervals, and only the fifth falls short of full protrusion, the upper two thirds of the crown appearing above the alveolar border. The base of a sixth tooth, with a large formative cavity is discernible, with the usual interval between it and the fifth. So much of the outer surface of

the bone as remains indicates a shallow longitudinal groove, nearly midway between the upper and lower margins, and disappearing beneath the second tooth in place; anterior to this the bone shows a few irregular shallow pits, some of which, occupied by matrix, indicate nervous or vascular foramina. In the same block are two fragments of, probably, the left ramus of the same jaw, each in connexion with, or lodging, a portion of a fully developed tooth.

A larger portion (fig. 3) which has been freed from another block, consists of the anterior part of the left mandibular ramus of the same skull, 8 inches in length, but wanting the symphysial end. On its outer side it repeats the longitudinal groove here extending backward three inches beyond the part interrupted in the right ramus. In advance of this groove there are similar depressions and indications of the small nervo-vascular foramina. As the lower border of the present fragment begins to bend upward at the anterior fracture, in a degree similar to the fore end of the right ramus, I conclude that not more than an extent of two to three inches are wanted to complete that end. The oblique fracture of the bone here exposes the hollow base of the crown of a functional tooth, and on its inner side is the partially calcified germ of the successor.

The inner surface of the ramus (Pl. 87, fig. 3) is flatter and smoother than the outer. It is traversed by a deeper, narrower, and better-defined longitudinal groove; partially divided at its hinder half by a low linear ridge, indicative of the groove having been traversed by two impressing soft parts, probably a nerve as well as a vessel. The main groove becomes shallower and wider as it advances, inclining from the middle to near the lower border of the inner surface. Part of the suture between the splenial and dentary elements is here seen.

The teeth indicated in the portion of the left ramus have been more or less broken away, but answer in number and relative position to the entire ones in the right ramus. The tooth rising to fill the space between the first and second is more advanced; and on the inner side of the present fragment are seen the crown-tips of other successional teeth, appearing at the inner side of the base of preserved portions of the fully developed teeth. At the intervals of these rising teeth are seen the "series of triangular plates of bone (*b*, *b*, fig. 3) forming a zig-zag buttress along the interior of the alveoli, and from the centre of each triangular plate, the bony septum which crosses to the outer parapet, and thus completes the alveolus,"[1] well described in the type example.

As respects the dental characters exhibited in the present series of fossils, I find nothing to add to the Discoverer's original and graphic descriptions and to the supplementary details afforded by the more complete mandible and teeth in the private collection of the Duke of Marlborough at Blenheim. In the restoration of the skull I have been guided by that of the largest existing carnivorous land-lizard

[1] Buckland, loc. cit., p. 395, pl. xl, fig. 1.

(*Varanus giganteus*) and it may prove that the post-orbital part of the skull is somewhat shorter than in fig. 5. Moreover, the present fossils impress me with the notion that they have come from a rather smaller individual than those yielding the subjects of the undercited plates.[1] But on these data and subsequent materials, I estimate the total length of the skull of *Megalosaurus Bucklandi* not to have exceeded 2 feet 6 inches; they do not support that of "four or five feet" ascribed to it by Professor Phillips.

In one of the blocks of quarry stone lodging a portion of the skull above described appeared a slender position of an elongate bone, which, on further exposure, suggested its interpretation as a dermal spine. It was 2⅔rds of an inch in length—68 millims.—with an expanded, seemingly basal half. The narrower part was 28 millims. in length, the broader part 40 millims. in length; this part extended on each side into a low angular plate, giving, between the angles, a breadth of 20 millims. Beyond or below these angles the spine contracts, but thickens. Both ends were broken off; the basal end giving a thickness or breadth of 7 millims.

On the hypothesis that this lamellate spine formed part of the dermal armour or appendages of the Megalosaur, the quest was excited of other palæontographical descriptions of extinct forms belonging or allied to the Dinosaurian order.

In the instructive volume,[2] issued by the accomplished Professor of Palæontology in the 'Musée d'histoire naturelle, Paris,' a description is given of an extinct reptile, from the Lower Permian of Igornay, France, under the name of *Stereorachis dominans*;[3] and, associated with remains of the skull and humerus, were "écailles en forme d'epines;" they are figured in numbers on the block with part of the skeleton, p. 280; and of the natural size, p. 284; they are smaller but similar in shape to that above described, and referred to the Megalosaur.

Genus—Bothriospondylus, *Owen*.

Species—*Bothriospondylus magnus*, Owen (*Dinosauria*, Plate, *nat. size*).

In the year 1874 I received portions of vertebræ from Wealden beds represented by blue shaly clay and much lignite, near Barnes' Chine, South Coast, Isle of Wight. They were referred to a genus named *Bothriospondylus*,[4] and the centrum of a dorsal vertebra was described and figured, as *Bothriospondylus magnus*, in a

[1] 'Dinosauria,' vol. i, pls. 24—32.

[2] 'Les Enchainements du Monde Animal dans les Temps Géologiques,' par Albert Gaudry, Membre de l'Institut, &c.

[3] Ib., pp. 279—284, figs. 281, 282, 283.

[4] Vol. i, p. 551.

Monograph of the genus, published in the volume of the "Palæontographical Society," for the year 1875 (p. 24, Pls. 8 and 9).

Subsequently I received from a contiguous part of that coast, and, from the character of the contained or adherent matrix, also from a Wealden bed, a larger vertebral centrum of longer proportions.

As this specimen was characterised by the unusual proportion of unossified tracts of the bony substance, which I infer to have been occupied by gristly matter, I proposed for it the name of *Chondrosteosaurus.*

Of this genus the centrum of a dorsal vertebra is described in vol. i, p. 622, and figured in *Dinosauria,* Pl. 79, affording an instructive subject of comparison with that of Pl. 83 of vol. iv.

Without a vertical diameter of the same dimensions, $7\frac{1}{2}$ inches, the present vertebra has a length of $8\frac{1}{2}$ inches, while that of *Chrondrosteosaurus,* from the same part of the vertebral column, is 1 foot, 3 inches in length; which seems to indicate something more than a specific distinction. The side-pit of the centrum repeats the generic characters shown in *Bothriospondylus suffossus* (vol. i, p. 555, *Dinosauria,* Pl. 63); and the free surface of the centrum, where entire, shows the same smoothness, as in the type specimens. But it is unnecessary to extend the description of the somewhat mutilated centrum, the subject of Pl. 83, as an almost entire vertebra, with the centrum but slightly mutilated at the borders of the hinder articular concavity, affords the subject of the folding plate, and of the present description.

The following are dimensions of this vertebra:

	Feet.	Inches.	Lines.
Centrum, length	0	8	6
„ breadth of fore articular end	0	9	0
„ „ of middle	0	6	0
„ height of ditto	0	6	6
Height of entire vertebra	2	4	0
Breath across diapophysis	1	8	6
Height of spine from between pregygapophyses	1	3	0

The anterior surface of the centrum, *c*, is moderately convex: the sides are concave lengthwise, excavated by a cavity, *c*, $5\frac{1}{2}$ inches in length, 3 inches in height, with the aperture of a narrow ovate form, $4\frac{1}{2}$ inches long, 2 inches high, at its fore part, contracting to almost a point behind; situated at the upper half of the side of the centrum. This cavity has a smooth surface, not communicating with or continued into the osseous tissue, and probably having served to lodge an air-cell continued from the lungs in the living Reptile.

The outer surface of the centrum beneath the pulmonic cavity, is continued by

a regular convexity into the under surface of the centrum which is broad, moderately convex across, and concave lengthwise. The border of the front articular surface, *c*, seems to be naturally bevelled off to a breadth of about half an inch, but becoming narrower near the upper margin of the convexity: this marginal tract may be due to abrasion. The margin of the hind concavity, *c′*, has suffered more obviously from such accidental cause.

The neural arch, *N*, manifests on a striking scale the dinosaurian complexity. It has coalesced with the centrum, leaving no sign of suture. The fore-and-aft extent of its base is 5 inches, thence it expands in length, breadth, and height, to develop the zyg. 22, and di. *d*, apophyses, and from this bony platform, five strong ridges rise to support and form the neural spine, *Ns*. Of these ridges the anterior pair spring from the prezygapophyses, converge and meet eight inches above their origin; and, rising for an inch or more, again diverge toward the summit of the spine, which is broken away. The lateral ridges or buttresses are continued with a regular curve from the upper border of the diapophyses, *d*, and also divide each into a pair of sharpish ridges, the anterior one being lost upon the side of the spine, the posterior division expanding into a broad, sharp plate, which is thickened as it is lost in the summit of the spine. The breadth of the neural spine, here, is eight inches, but does not exceed four inches at its mid-length, or height. The hind surface of the spine is traversed by a longitudinal medial ridge, *r*, commencing from the fossa between the post-zygapophyses, increasing in breadth as it rises, and again narrowing or subsiding upon the broad, flattened hind part of the summit of the spine, *Ns*.

The neural canal, *Nc*, shows the usual reptilian, cold-blooded, contracted area: the anterior aperture, of a full transversely oval shape, has but 2 inches in long diameter, and $1\frac{1}{4}$ inches vertically. Here the breadth of each neurapophysis is barely 2 inches, but they rapidly thicken or expand as they rise and develop the prezygapophyses, 2. The breadth of each of these processes at its upper or articular end is 3 inches; the articular surface looks upward with a slight inclination inward and forward. From the centrum to this surface measures 5 inches; the breadth across both surfaces is $6\frac{1}{2}$ inches. From the outer side of the pedicle or base of the neurapophysis a narrow ridge ascends, increasing in breadth to the base of the platform external to the prezygapophysis; it terminates abruptly before reaching the fore part of the base or origin of the diapophysis. From the fore part of this ridge are sent off two oblique ridges, subsiding upon the front surface of the supports of the prezygapophyses, and dividing the outer portion of that front surface into three smooth depressions, augmenting in size as they ascend. The fore part of the base of the diapophysis begins by a pair of horizontal ridges, one from the outer border of the prezygapophysis, the other from the base of the contiguous vertical ridge, ascending and converging to its

fellow for strengthening the neural spine. The two short ridges converge and unite to form the anterior plate of the diapophysis; a deep triangular pit intervenes between these two anterior converging transverse ridges. From the upper part of the diapophysis a strong and broad compressed plate curves upward to abut upon the side of the neural spine; as it approaches the spine it divides, the shorter and lower division terminates about 6 inches from the summit of the spine, the longer and sharper division attains the outer part of the spine's summit. A deep and large triangular fossa is bounded by the anterior ridge of the neural spine, by the antero-transverse ridge of the diapophysis below, and by the upper diapophysial ridge behind. The depth of this fossa is 5 inches.

The diapophysis derives its origin also from two other plates of bone: one, *a*, nearly vertical and inferior, commences a little above the base of the neurapophysis, rather nearer the hind than the fore part; it rises and is lost upon the under surface of the diapophysis, which it seems to support. The outer border of this plate is 5 inches in extent, the greatest breadth is $3\frac{1}{4}$ inches; it constitutes the hind wall of the large anterior neurapophysial cavity, *o*. The back part of the diapophysis is formed by a horizontal plate, *b*, beginning at the origin of the postero-lateral buttress of the neural spine; thence it extends, losing breadth, to the hinder and under surface of the diapophysis. This diapophysial plate is horizontal, and forms the floor of a deep triangular posterior fossa, *t*, at the base of the neural spine; the depth is 3 inches.

The diapophysis with this four-ridged complex origin extends, measured from the bottom of the anterior interspace between the horizontal and the vertical plates of origin, 10 inches in an almost directly outward course; the triedral form changes beyond the middle of this length to a subelliptic one, which swells out into a large oblong terminal tuberosity, *d*, with the articular surface for the rib bevelled off obliquely from its upper part.

The four-fold buttress-plates bespeak the size and weight of the rib supported by this process. As there is no parapophysis it may be inferred that the present vertebra has come from a part of the dorsal series behind the anterior ones which have developed their lower process for a double articulation of the rib.

The concavity at the hind part of the centrum, *c*, corresponds in shape and depth with the ball at the fore part; the margin of the cup is more or less broken away. The outlet of the neural canal, *N c*, is more oblique than the inlet, but has a similar small area. Above it is a deep triangular cavity, the side-walls of which, as they ascend and converge, curve backward and unite in a point which slightly overhangs the centrum. The depth of the cavity so formed is $3\frac{1}{2}$ inches. Above the roof of this cavity are a pair of smaller fossæ, and above these the broken base of the neural arch from which the post-zygapophyses had been developed. A deep median pit is excavated between the bases of the post-zygapophyses, and

from the bottom of this pit rises the thick and strong posterior ridge of the neural spine.

Measured from the origin of this ridge, the spine rises to a height of one foot; the breadth of the spine at its mid-height is three and a half inches; but it expands as it rises to twice that breadth; and both the sides and summit of this expanded part have suffered loss.

The least injured part of this extraordinarily complex bone is the right side: but sufficient remains of the left side to indicate corresponding ridges, plates, cavities and other sculpturings of the osseous substance, the characters of which I have here attempted to describe.

I may remark that the Saurian vertebræ hitherto discovered, which have the convex and concave terminal surfaces of the centrum on opposite sides to those which they hold in modern *Crocodilia*, and which have suggested to V. Meyer the term *Streptospondylus;* also differ from the true *Crocodilia* by a complexity and development of the neural arch, which indicates their position to be among *Dinosauria.*

SUPPLEMENT TO CHAPTER II.—*Ichthyopterygia.*

Ichthyosaurus fortimanus, Owen.

In the pectoral paddle of *Ichthyosaurus latimanus* (*ante* p. 83, Pl. XXIX, fig. 1), of which the vertebral characters are described and figured (ib., figs. 2 and 7), five digital series are recognisable by their angular characters, besides the radial and ulnar marginal smaller rounded series. In *Ichthyosaurus fortimanus*, with a paddle of equal breadth in proportion to the length, there are four digital series according to the relative size and angularity of the phalanges; and, if a fifth series should answer to the fifth (ulnar) digit of *Ich. latimanus*, its phalanges are reduced to the smaller size and rounded shape of a marginal series; but as they are bordered by a true marginal series of still smaller rounded ossicles, such reduction of the representative fifth or ulnar digit adds a second specific distinction to the pectoral paddle of *Ich. fortimanus;* the relative breadth of the fin being mainly due to the larger relative size, especially breadth, of the phalanges of the 1—4 digits.

Ichthyosaurus longimanus, Owen.

In the same Plate is represented a well-preserved pectoral fin, as remarkable for its relative length as those of the two above-named species are for breadth; yet the five normal digits and the marginal supplementary series enter into its formation. The phalanges here are notable for their great number in each digit,

especially in the third, fourth, and fifth of the series. The anterior marginal now presents, indeed, the characters of a normal digit, and by its articulation with the radio-carpal ossicle seems to displace the foremost or true radial from its carpal or metacarpal connection. At the ulnar border of the modified paddle are two series of the small rounded marginal ossicles; nevertheless the number of phalangeal and marginal ossicles is such that the chief characteristic of this paddle is its superior length in proportion to its breadth.

SUPPLEMENT TO CHAPTER I.—*Sauropterygia.*

Plesiosaurus macrocephalus, Owen. Enaliosauria, Pl. 17.

For the unique specimen figured in the above plate the British Museum is indebted to the Earl of Enniskillen, who, when Lord Cole, obtained it during one of His Lordship's visits to Lyme Regis in quest of the fossils from the Liassic deposits in that locality; and I was favoured by its transmission for determination and description. It was in a rare condition of preservation, as may be conceived by the Plate, and obviously differed from the species, at that date (1838), described and figured by Conybeare and Hawkins.

The first distinction which arrested attention was the greater relative size of the skull. (Compare Pl. 17 with Pl. 1, *Plesiosaurus dotichodeirus* and Pl. V, *Plesiosaurus homalospondylus.*) In correlation with the weightier head is a relatively stronger and shorter neck, though this retains sufficient of the characteristic proportion of the part in the present singular extinct Order of marine Reptilia: it is twice the length of the lower jaw, and includes twenty-nine vertebræ. Differential characters are also shown in the proportions of individual vertebræ; in the twentieth, counting from the skull, the transverse is to the fore-and-aft diameter as 2 to 1; in a corresponding vertebra of *Plesiosaurus Hawkinsii* it is as 4 to 3. The short cervical ribs, which, as usual in the Order, are mostly hatchet-shaped, resume the more normal syliform character at the twenty-fifth vertebra; in *Plesiosaurus homalospondylus.* This change does not take place until the twenty-ninth vertebra, the number of cervicals being thirty-one; in *Ples. macrocephalus* it is twenty-nine. I still adhere to the character defining the cervicals in the present long-necked Reptiles, viz. holding that vertebra in which the costal articular surface has risen from the centrum to the neurapophysis, as the first or foremost of the dorsal series. As many successive vertebræ as show the rib-bearing processes on the neural arch I reckon as "dorsals." Of these there are twenty in *Ples. macrocephalus*, and twenty-three in *Ples.*

Hawkinsii. In both species the terminal dorsals may answer to the lumbars in *Crocodilia;* but no vertebra is ribless in *Plesiosaurus* until they approach in position towards the end of the tail. There are no sacral vertebræ, the pelvic arch being freely suspended. In *Pl. macrocephalus,* at the fiftieth vertebra (from the skull), the rib descends from the neural arch upon the centrum; in *Ples. homolaspondylus* the change occurs in the sixty-eighth vertebra; in all kinds the rib disappears in the terminal caudals.

In the skull so much of the parietals are preserved as to show that the medial suture persists, that they diverge, behind, to receive the superocipital, and that they retain the pineal foramen near their suture with the frontals; in these characters is shown a nearer affinity to Lacertilian than to Crocodilian modifications of the skull. The mid-frontals extend forward to between the parial outer nostrils, the interfrontal suture rising, ridge-like, to be continued into that which extends forward along the nasals and premaxillaries. The nostrils open on the upper surface of the skull a little anterior to the orbits, facilitating respiration in the aquatic air-breather. The post-frontal is narrower than in *Ples. Hawkinsii,* but, as in that and other Plesiosaurs, does not extend to join the mastoid. The tympanic shows the strong proportions characteristic of the genus. The mandible has the usual compound structure, with a coronoid eminence well developed. The broad coracoid and the scapula, in position and shape corresponding with the Plesiosaurian type, are well displayed on the left side of the specimen; the framework of both pectoral and pelvic fins is sufficiently well preserved in the subject of Plate 17 to enable me to dispense with verbal description; it shows well-marked modifications of structure as compared with the same parts in the *Plesiosaurus rostratus,* which most resembles *Ples. macrocephalus* (*Sauropterygia,* Plate 9) in the proportions of head and neck.

Species—*Plesiosaurus brachycephalus,* Owen (*Enaliosauria,* Plate 15).

The proportion of the skull to the cervical vertebræ, which are the same in number and relative size to those in the previous species, suggested *The nomen specificum.* The skull is also shorter in proportion to its breadth. Notwithstanding the difference, the strength of the neck, as indicated by the processes of the cervical vertebræ, must have exceeded that of *Plesiosaurus macrocephalus.* The fin-bones, as indicated by the humeri, and those preserved of the left pelvic limb, were less powerfully developed. A portion of a Liassic Ammonite is preserved in the mass of matrix on which the skeleton of the contemporary sea-dragon reposes.

SUPPLEMENT TO VOL. I.—CHAPTER I. ORDER—CHELONIA.

Genus—PLEUROSTERNON, *Owen*.

As a general rule the vertebrate animals of the Mesozoic strata manifest, in the modifications of their structure, a nearer approach to the archetype of their sub-kingdom than the tertiary and existing Vertebrates do. This rule is exemplified in the present genus of Chelonian Reptiles by the accessory osseous pieces that enter into the formation of the plastron, and which are interposed, as an additional pair of bones, between those more constant parial elements called "hyosternals" (*h s*, Plate 54) and "hyposternals" (*p s*, ib.), and which alone articulate with the marginal pieces (*m, m*) in existing Emydians. At least, if we adopt the general homology of the parial elements of the plastron, indicated by the development of that part, viz. as being hæmapophyses,—an increased number of such pieces, making them to that degree more equal in number with the pleurapophyses of the carapace, offers an obvious tendency to a return to the normal type; and the fact of a genus or family of extinct secondary Chelonians manifesting such increase in the number of parial pieces, gives additional support to the conclusions as to the nature of the plastron arrived at from a study of that part in the embryos of existing species.

By the name *Pleurosternon* it is desired to intimate the characteristic furnished by the additional number of inferior rib-elements (hæmapophyses, or "cartilagines costarum" of Anthropotomy) composing the under-shell or plastron.

The extent of the ossification of the carapace and plastron, and the firm union of the roof and floor of the bony chamber by the medium of the side-walls, afforded by certain marginal plates, prove the genus not to belong to the *marine Chelonia;* the presence of the marginal plates, and the impressions of the horny scutes which covered the carapace and plastron, forbid its being referred to the *fluvial* tribe, represented by the *Trionyces;* the depressed shape of the carapace excludes it from the *terrestrial* tribe of true Tortoises; and we arrive, therefore, by the way of exclusion, to the association of the genus in question with the Terrapenes and other members of the family *Paludinosa.*

PLEUROSTERNON CONCINNUM, *Owen*. Plates 53, 54.

The subjects of the above Plates consist of a nearly entire carapace and plastron. They are from the Purbeck Limestone, Swanage, Dorsetshire.

The carapace (Plate 53) includes the nuchal plate (*ch*); the eight neural plates (*s* 1—*s* 8) which are connate with the neural spines of the vertebræ of the carapace; and the corresponding eight pairs of costal plates, except the eighth on the right side (*pls.* 1—8). The hindmost neural plates, and all the marginal plates, save the first of the left side connected with the nuchal plate, are wanting.

The length of the carapace, from the anterior margin of the nuchal plate to the posterior one of the eighth neural plate, is 13 inches; the breadth of the carapace, across the third costal plates, is 11 inches. The outer surface of the carapace is very slightly convex.

The nuchal plate (*ch*) is six-sided; the anterior and antero-lateral borders are of equal length, and are the longest of the six; the hind border is the shortest: the latter is angularly notched for the reception of the first neural plate (*s* 1). The front border is slightly convex, with a feeble median concavity. The greatest breadth of the nuchal plate, which is across the angles between the antero-lateral and postero-lateral borders, is 3 inches 4 lines; the length of the nuchal plate is 2 inches 3 lines. The outer surface of the nuchal plate is impressed by a triradiate groove, indicative of the junction of the two nuchal scutes with each other and with the first vertebral scute (*v* 1). The portion of the median series of bony plates answering to the first neural plate in ordinary Chelonia is divided by a transverse suture into two plates,—a circumstance which corroborates the homology of the neural plates with the median dermal bones of the Crocodilia, and opposes their interpretation as the vertebral spinous processes unwontedly expanded. The indented boundary between the first (*v* 1) and second (*v* 2) vertebral scutes crosses the first neural plate (*s* 1) immediately in advance of the dividing suture in question.

The second (*s* 2) to the eighth (*s* 8) neural plates inclusive are six-sided, with the antero-lateral sides or borders the shortest, and the postero-lateral ones the longest; the third, fifth, and eighth are crossed by the boundary impressions between the vertebral scutes. They progressively diminish in length to the seventh; the eighth resuming the normal length, unless the indentation between the fourth (*v* 4) and fifth (*v* 5) vertebral scutes conceal, as I suspect, a suture dividing the plate (*s* 8).

The first pair of costal plates (*pl.* 1) is impressed by the boundary lines dividing the second marginal scutes, the first vertebral scute (*v* 1), the second vertebral scute (*v* 2), and the first costal scute (*c* 1); it unites with the nuchal (*ch*) and first and second marginal plates, with both divisions of the first neural plate (*s* 1) with the anterior truncated angle of the second neural plate (*s* 2), and with the second costal plate (*pl.* 2); the second (*pl.* 2) to the seventh (*pl.* 7) costal plates have the posterior angle of their mesial extremity truncated; they become slightly expanded at their lateral extremity; and, after the third, they gradually decrease

in length. The second, fourth, and sixth costal plates, like the first costal plate, bear the impressions of the lines of union of the costal scutes with each other and with the vertebral and marginal scutes; the third, fifth, and seventh costal plates bear the impressions of the lines of union of the costal with the vertebral and marginal scutes. The eighth costal plate is impressed by the line of union between the fourth costal scute and the fifth vertebral scute, and by that of both these scutes with the fourth vertebral scute mesially, and with the tenth marginal scute laterally.

The exterior surface of all the above-described elements of the carapace is minutely wrinkled and granulated, except near the sutural borders, where it is impressed by numerous close-set fine lines, directed at right angles, or nearly so, with those borders. This two-fold pattern is best marked in the costal plates, in most of which the marginal lineated sculpturing extends over about one fourth of the entire breadth of the scute. There are no concentric impressions indicative of the lines of growth of the horny scutes.

The first marginal scutes meet at the middle line on the forepart of the nuchal plate, and do not leave there any median or nuchal scute in the present species. The first and second vertebral scutes are of equal breadth, the succeeding three progressively decrease in breadth: all are six-sided, and broader than they are long, the length and breadth being most nearly equal in the fourth vertebral scute (*v* 4).

The following are the dimensions of the principal vertebral scutes:

	First.		*Second.*		*Third.*		*Fourth.*	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Length, or antero-posterior extent .	2	6	2	11	2	11	3	0
Breadth	4	10	4	10	4	7	3	6

Their shape is sufficiently indicated in the figure (Plate 53); as is also that of the costal scutes *c* 1 to *c* 4.

In the carapace above described the greater part of the marginal plates, the eighth costal plate of the right side, and the terminual neural plates, are wanting; but sufficient remains in natural juxtaposition to show that the carapace has been of a full oval figure, broadest anteriorly, with a very slight degree of convexity, and without any special elevations along the median line or at other parts.

The plastron (Plate 54) is a long, rather narrow, flat, oval plate; it was probably rounded anteriorly, but this border is fractured: it contracts from the lateral wall (*h s*, *p s*) with a gentle sigmoid marginal curve to the hinder apex (*x s*), which is notched. The middle third of each lateral border of the plastron is connected, through the medium of three marginal plates, with the carapace. The length of the plastron, as far as it is entire, is 13 inches; its breadth, at the fore part of the lateral walls, is 6 inches 6 lines.

The entosternal element (*s*) is as broad as it is long; its anterior half is defined by two nearly straight borders, which converge at an angle of 45°; its posterior contour is semi-circular; the length of the entosternal is 2 inches 4 lines. The episternal (*e s*) is bounded behind by two nearly straight lines, which meet at an open angle. The hyosternal is remarkable, as in other species of *Pleurosternon*, for the excess of its transverse over its antero-posterior diameter, as compared with the same element of the plastron in other *Paludinosa:* the median sutural border is irregularly wavy: the lateral border united by suture with the fifth and part of the sixth marginal plates, the anterior border is united by suture at its median half to the entosternal and episternal bones; its lateral half is free, smoothly rounded, and indented by a deep and narrow notch. The outer surface of the bone is impressed by the line dividing the humeral from the pectoral scute, which line is crossed at right angles by the line dividing both the above scutes from the axillary and submarginal scutes.

The supplementary sternal elements, intercalated between the hyosternals (*h s*) and hyposternals (*p s*) and which, from their constancy in the present genus, I propose to denominate, for the convenience of description, the "mesosternals," and which bear the letters (*p e*) and (*a b*) in Plate 54, are transversely elongated, quadrate plates of bone, resembling in form the costal plates above, and being their correlatives in the plastron. They are not quite symmetrical in the present specimen, the left one having a greater antero-posterior breadth, and encroaching a little way beyond the median line to the right side of the plastron to join its fellow: at the outer end they articulate with part of the sixth and part of the seventh marginal plates. The mesosternal element is impressed by the line dividing the pectoral (*p e*) from the abdominal (*a b*) scutes; and by that dividing both these from the submarginal scutes. The hyposternals (*p s*) present nearly the same proportions as the hyosternals (*h s*); they unite externally with part of the seventh marginal plates; they are impressed by the straight transverse line dividing the abdominal from the femoral scutes, and by that dividing these from the inguinal scutes. The xiphisternals (*x s*) present the form of an inequilateral triangle, and are impressed by the line dividing the femoral (*f e*) from the anal (*a n*) scutes. The forms and proportions of the perishable horny scutes that covered the bony plastron are indicated by the narrow, well-defined impressions of their boundary lines. The line dividing the intergular from the humeral scutes curves across the entosternal at about one third of the length of that bone from its anterior border. The humeral scutes (*h u*) covered the rest of the entosternal (*s*) part of the episternal (*e s*) and the anterior half of the hyosternal (*h s*) bones. The pectoral scutes (*p e*) were transversely elongate, quadrate, and covered the posterior half of the hyosternals and the anterior third of the meso-sternals. The abdominal scutes (*a b*) presented a similar form, and covered the rest of the mesosternals and less than

half of the hyposternals. The femoral scutes (*f e*) were longer than they were broad; they joined the abdominal scutes by a straight transverse line; but that between them and the anal scutes (*a n*) describes a curve, with the convexity backwards, and nearly equally divides the xiphisternals (*x s*). In addition to the axillary and inguinal scutes, there are three scutes interposed between the outer borders of the pectoral and abdominal scutes, and the under borders of the fifth, sixth, and seventh marginal scutes: these superadded scutes I propose to call "submarginal scutes." The *Platysternon megacephalum*, or Large-headed Terrapene of the Chinese swamps, presents a corresponding, but single, supplementary "submarginal scute" upon the under part of each lateral production of the plastron. The under surface of the fifth, sixth, and seventh marginal plates bears a crucial impression, indicative of the lines of junction between the marginal and submarginal scutes. The head of the left femur is preserved, near the seventh marginal plate, in the specimen above described.

PLEUROSTERNON EMARGINATUM, *Owen*. Plates 55, 56.

This is a nearly-allied species. It is from the same formation and locality, and differs from the foregoing chiefly in the contour of the free borders of the plastron. The nuchal and first marginal scutes are wanting in the specimen with the upper surface of the carapace exposed (Pl. 55). The neural plate answering to (*s* 1) in ordinary Chelonia is divided by a transverse suture in this species, as in *Pl. concinnum*, and the impression of the line of union between the first and second vertebral scutes crosses just in front of the suture of division. The second neural plate (2) joins the first costal plate of the left side, but not that of the right; and it is pentagonal, the shortest side or border being that which joins the left first costal plate. The third (3) to the seventh (7), neural plates inclusive are hexagonal, and resemble in shape those in the *Pleurosternon concinnum;* the eighth neural plate is hexagonal, and is broader than it is long; the ninth neural plate answering to that bearing the letter (*s* 8) in Pl. 53, is more expanded at its hinder part; the tenth neural plate (10) is triangular, with a truncated apex and a broad rounded base, which articulates with the pygal and adjoining marginal plates. The second and third marginal plates bear not only the impressions of the lines dividing the corresponding marginal scutes from each other, but those dividing the marginal from the first costal scutes. The succeeding costal scutes do not encroach on the marginal plates, which consequently only show the impressions dividing the marginal scutes from each other. Some of the marginal scutes are slightly dislocated, and the posterior ones, from the ninth to the pygal scute inclusive, have their free borders mutilated.

The first vertebral scute (*v* 1) is narrower than the second and third vertebral scutes, instead of being broader, as in *Pleurosternon concinnum.* The second vertebral scute (*v* 2) is proportionally broader behind than is its homologue in *Pl. concinnum.* The fifth vertebral scute (*v* 5) has the three angles of its hinder border sharply produced in the interspaces between the last marginal scutes.

The character of the outer surface of the carapacial pieces resembles that in the *Pleurosternon concinnum.*

The more entire posterior border of the carapace of a second specimen from the Purbecks shows it to be slightly emarginate at the middle of that border; and there is sufficient of the anterior border of the same carapace preserved to show that it is more widely and deeply emarginate at the middle of that end.

With regard to the plastron (Plate 56), the lateral borders of the anterior freely-projecting portion are straighter, and those of the posterior portion more uniformly convex, than in the *Pleurosternon concinnum;* the terminal notch has its sides concave instead of convex. The impression of the line dividing the humeral (*h u*) from the pectoral (*p e*) scutes advances at the median plane so as almost to touch the entosternal (*s*). The mesosternals differ from those of the *Pl. concinnum* by the right extending a little to the left of the median line, but not more than may be expected from the admitted extent of variety in different individuals of the same species. The line between the femoral (*f e*) and anal (*a n*) scutes is wavy, instead of being simply convex, as in *Pl. concinnum.* The impressions of the three accessory (submarginal) scutes, between the axillary and original scutes, on the right side of the plastron, are well shown; they have not encroached so far upon the marginal plates as in the *Pl. concinnum.*

The length of the carapace of the *Pleurosternon emarginatum,* in the specimen figured in Plate 55, is 21 inches 9 lines; the breadth of the carapace is 20 inches. The entire length of the carapace is about 17 inches; the breadth about 15½ inches.

PLEUROSTERNUM OVATUM, *Owen.* Plate 57.

The most perfect example of the depressed Emydians, with the complex plastron, from the fresh-water Limestone of Purbeck, is that figured in Plate 57.

The entire series of marginal plates is preserved with scarcely any dislocation or fracture, in natural connection with the costal plates: they show the carapace to have been nearly elliptical in figure, but a little more pointed, or less obtusely rounded behind than before; it is not emarginate at the anterior border, and was only very slightly so, if at all, at the posterior border. The *Plerosternon concinnum* resembles the *Pleurosternon ovatum* in the absence of the anterior emargi-

nation of the carapace, which distinguishes the *Pleurosternon emarginatum*. The first vertebral scute (*v* 1, Pl. 57) is narrower than the second, instead of being of equal breadth, as in the *Pl. concinnum:* it covers, also, a larger proportion of the first neural plate (*s* 1), which, moreover, is not divided into two, as in the two previously described species. The place of the fourth neural plate is occupied by the conjoined median ends of the fourth pair of costal plates, ossification having extended continuously from them into the dermal matrix overlying the subjacent neural spine, instead of commencing from that spine or from a separate centre; but this may be an individual variety. It leads, however, to a modification of form of the fifth neural plate (*s* 5), which is pentagonal, instead of being six-sided, as is usual, and as is the case with the two succeeding neural plates. The eighth neural plate expands posteriorly, and the expansion in this direction is progressive in the ninth and tenth neural plates; the eleventh or pygal plate (*p y*) is narrower than the back part of the tenth neural plate, is quadrate, and shows, both by its shape, size, and median impression, that it belongs rather to the category of dermal marginal plates, the series of which it completes posteriorly. The costal plates (*pl.* 1 to *pl.* 8) offer no modification worthy of notice. There are eleven marginal plates (1, 1′, to 10) on each side of the carapace, in addition to the nuchal (*c h*) and pygal (*p y*) plates; they increase in breadth after the sixth; the first bears the impression of the triradiate line which marks the division between the first (*m* 1) and second (*m* 2) marginal scutes, and the first (*v* 1) vertebral scute.

There is no nuchal scute. The second, third, and fourth marginal plates are slightly overlapped by the first costal scute (*c* 1). The antero-posterior breadth, in comparison with the transverse breadth, is greater in the costal scutes of the *Pleurosternon ovatum* than in those of the *Pleurosternon emarginatum*. The number of marginal scutes is twenty-four, twelve on each side (*m* 1 to *m* 12).

The fore part of the plastron appears to have projected in advance of the carapace, as is indicated by the plate of bone marked (*e s*) in Plate 57.

The length of the carapace of the specimen of *Pleurosternon ovatum* here described is 19 inches 6 lines; its breadth is 14 inches 6 lines. It is very slightly convex, with the margins a little raised. The feeble sculpturing of the outer surface of the carapace resembles in general character that of the other species of *Pleurosternon*.

PLEUROSTERNON LATISCUTATUM, *Owen*. Plate 58.

The species represented by the specimen of mutilated carapace, here figured, differs from all the other recognised species of the genus by its distinct nuchal scute (*ch*), by the small relative size of the first vertebral scute (*v* 1), and by the

great relative size, more especially the superior breadth, of the three succeeding vertebral scutes (*v* 2, *v* 3, *v* 4). The boundary lines, indicating the forms and disposition of the horny scutes, are proportionally larger and deeper than in the other species of *Pleurosternon* which have come under my observation.

The sutures uniting together the different elements of the carapace are more dentated or wavy, more especially the suture uniting the nuchal plate with the first neural plate and first pair of costal plates. The neural plates, from the first to the seventh inclusive, are similar in form, six-sided, with the antero-lateral sides the shortest; the eighth neural plate is the smallest, is four-sided, and broadest behind; the ninth and tenth neural plates are remarkable for their great breadth.

The transverse extent or length of the costal plates is considerable, in accordance with the great breadth of the carapace: the eighth costal plate, in this respect, differs considerably from its homologue in the other species of *Pleurosternon.* The second marginal scute is not produced backwards between the first vertebral and first costal scute, but, like the first and third marginal scutes, has its antero-posterior diameter much less than the diameter in the direction of the periphery of the carapace. The first (*c* 1) and fourth (*c* 4) costal scutes differ considerably in their forms and proportions from those in Plates 53, 55, and 57.

The outer surface of the osseous parts of the carapace of *Pleurosternon latiscutatum* is minutely punctated and rugose, except near the sutural borders of the several pieces, where it is impressed by rather coarse parallel striæ, directed at right angles to those borders.

Genus—Platemys.

Platemys Mantelli, *Owen.* Plate 52, fig. 1.

Amongst the Chelonian Fossils from the Wealden strata of the Tilgate Forest, in Sussex, are certain specimens which resemble the flat species of Emydian, or terrapene, discovered by M. Hugi, in the Jura limestone at Soleure. Both the Jura species and the Wealden Chelonites in question are referable to the 'pleurođeral' section of the great tribe *Paludinosa,* as arranged by Messrs. Duméril and Bibron;[1] and, in that section, to the genus *Platemys.*

The most intelligible fragment in the British Museum, is that element of the plastron—the hyosternal, which is figured in the above Plate. The proportions of this bone indicate that the plastron of the *Platemys Mantelli* consisted of the

[1] 'Erpetologie,' 8vo, 1835, tom. ii, pp. 172, 372.

ordinary nine pieces : where the accessory pair of mesosternal pieces is introduced, both the hyo- and hypo-sternals have relatively less antero-posterior extent than the fossil in question shows.

PLATEMYS, sp. dub. Plate 52, fig. 2.

A second species of Wealden *Platemys* is apparently characterised by a somewhat broader plastron, and by a greater relative thickness of the bones composing both this and the carapace. Without the latter difference, the proportionally broader plastron might be merely the sexual distinction of the female of the first species. Some difference, in the shape of the axillary notch of the hyosternal further induces me to regard the fragmentary Chelonites in question, of which a hyosternal is figured in Plate 52, as belonging to a second species of Wealden *Platemys*.

PLATEMYS DIXONI, *Owen*. Plate 52, fig. 3.

A Platemydian specifically distinct from either of the above is more unequivocally exemplified by the sternal element represented in figure 3 ; the matrix having been carefully removed from the outer surface of this fossil, the linear impressions which have divided the humeral from the pectoral scute, and this from the abdominal scute, are clearly shown. The positions of these transverse grooves accord with those in the hyosternal of the Emydians, having the usual number (nine) of plastral elements : and the hyosternal character of the fossil is further shown by the oblique border cutting off the inner angle of the anterior end, for articulation with the entosternal element. (This end has been figured downwards in the plate.) The axillary groove is narrower than in the above-described species ; and the whole bone seems to have been longer in proportion to its breadth. It is from the Wealden of Tilgate Forest, and formed part of the Collection of the Author of the instructive Work, 'On the Cretaceous and Tertiary Formations of Sussex,' Frederic Dixon, Esq., F.G.S.

Genus—CHELONE.

CHELONE COSTATA, *Owen*. Plate 51.

From the Wealden Clays of Tilgate Forest have been obtained many fragmentary Chelonites, indicative of species representing two of the actual families of the order, viz. *Paludinosa* and *Marina ;* and such, therefore, as might be expected

to be met with in the deposits of a large estuary. I commence the description of these Wealden Chelonites by those which indicate a species of the marine family.

Portions of the carapace and plastron, and bones of the extremities of a large species of Turtle, some of them indicating individuals with a carapace nearly three feet in length, form part of the Mantellian collection, purchased by the Trustees of the British Museum, and now in the Museum of Natural History, Cromwell Road.

After comparison of these specimens I have come to the conclusion that the Wealden species differ from *Chelone imbricata*, *Chelone carinata*, and other recent species, in as great a degree as do most of the Eocene *Chelones*, in the greater extent of ossification of the costal interspaces and of the plastron.

A characteristic portion of the great Wealden Turtle is represented, of the natural size, in Plate 51. It includes the second and third marginal plates, and considerable portions of the first and second costal plates, with the connate portions of the pleurapophyses, or vertebral ribs. These are remarkable for their breadth and prominence, and have suggested the name proposed for the present species.

In the same plate are represented a mutilated right iliac bone (fig. 3) and the right femur (fig. 2) of, probably, the same species of Turtle. These, also, are from the Wealden formations of Tilgate Forest.

Figure 4, Plate 52, gives a view of the inner surface of the left hyposternal, half the natural size of, probably, the same species of *Chelone*. It is embedded in a slab of Wealden stone.

As compared with existing Turtles, the ossification of the plastron is more, advanced or more extensive, the rays of bone from the outer and inner free borders of the hyposternal being shorter and their interspaces more filled up. A nearer approach is thus made in this Wealden species, as in some of the Eocene Turtles, to what may be regarded as the more general type of the Chelonian carapace.

Chelone gigas, Owen. Plates XXX, XXXI.

In the course of the determination and description of the fossil remains referable to the marine genus *Chelone* (Turtles) fragmentary specimens from the Eocene clay of the Isle of Sheppey indicated the then existence of a species, as shown in fig. 5, Plate 40, much larger than those described in Vol. I, pp. 7—44. Recently, however, have been acquired from that locality, for the Palæontological Department of the British Museum of Natural History, remains of this giant of the Family *Marina*, of which I have selected for illustration the skull, represented in *Chelonia*, Plate XXX, of the natural size, viewed from above; other views of

the same remarkable fossil being given, reduced to one third the natural size, in Plate XXXI, Vol. IV.

By a comparison of these figures with those of the skulls of other extinct species which have left their remains in the same formation and locality it will be seen that besides difference of size, which is sufficiently remarkable, there are also proportional characteristics which compel a reference of the giant of the marine family to a distinct species. The entire skull is more flattened and depressed. This is shown in figs. 1 and 3 of Pl. XXXI. If they be compared with figs. 1 and 3, Pl. XI (*Chelone cuneiceps*), Vol. II, which offers the nearest approach to *Ch. gigas* in this character, the difference will be obvious. It is not wholly due to posthumous pressure, although this has produced a partial dislocation, as shown by the slightly bent super-occipital in fig. 3, and the shape of the orbit in fig. 1, Pl. XXXI. The plane of the nostril is wholly upon the upper surface of the skull, and is relatively nearer to the orbits, and further from the anterior premaxillary part. A transverse line across the back part of the nostril crosses the orbit very little in advance of the hind part of the anterior third of that cavity, a rare relative position of the nostril which could not have been induced by mere pressure. The orbits open upon the anterior half of the skull. The premaxillaries are produced beyond the nostril for a greater relative extent than in any of the extinct kinds, in some of which, for example *Chelone longiceps* (Pl. XII, fig. 2), Vol. II, the plane of the aperture is the same with that of the fore slope of the skull. In the recent Turtles, *Chelone mydas*, for example, the nostril is terminal, and its plane almost vertical, and it opens wholly in advance of the orbits. These apertures are relatively smaller in *Chelone gigas* than in any recent and in most extinct species.

All the cranial characters of the marine family of the order *Chelonia* are present in the gigantic extinct species.

Order—LABYRINTHODONTIA.

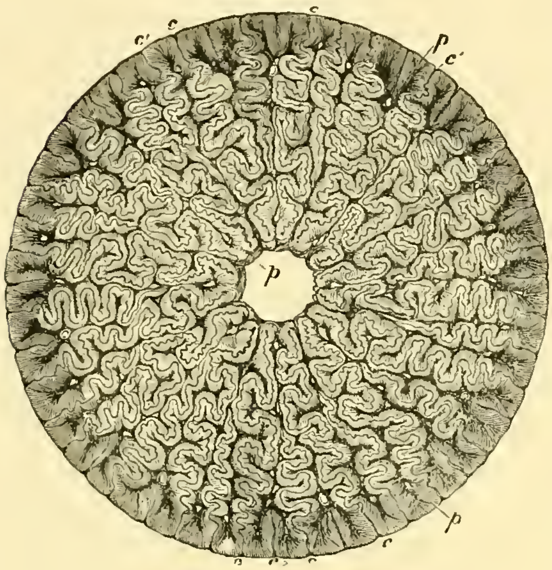
Genus—Labyrinthodon, *Owen*.

A knowledge of the chief character of the present Order and Genus was derived from examination of portions of petrified teeth found in a quarry of the New-red Sandstone at Coton End and Guy's Cliff, Warwickshire, and transmitted to me for determination and description by Murchison and Strickland.[1] The specimens received indicated a tooth of the common canine character, but straight

[1] See their paper in the 'Transactions of the Geological Society,' 4to, vol. v, Part ii, 1840.

and with a subcircular transverse section: the surface was traversed by close-set longitudinal lines, seemingly indicative of fissures. Being at that time engaged in a study of the teeth of Vertebrates, I submitted the fossils to microscopical scrutiny, and great was my surprise to see, in a transverse section, the structure figured in the subjoined Cut, fig. 1.

FIG. 1.—Section of tooth of *Labyrinthodon*.



The question which chiefly interested my geological friends was whether the sandstone was, as they suspected, of Triassic age, and might be equivalent to the German "Keuper Sandstone." Now, from this sandstone had been obtained fossils of a large Vertebrate species, referred by Professor Jaeger[1] to a genus he termed *Mastodon-saurus*. Of this species one of the fossil teeth presented the same conical, transversely circular, shape and longitudinal striation of the Warwickshire fossil. I therefore wrote to the author requesting the favour of a tooth of the *Mastodonsaurus*, which was promptly and kindly granted. Of this tooth slide-sections for the microscope were prepared and a labyrinthic interblending of the dental tissues was displayed, identified with the structure so unexpectedly brought to light in the fossil teeth from the Warwickshire Trias. Subsequent acquisitions of fossil remains, for which I am indebted to Dr. Lloyd, of Leamington, have enabled me to add the following illustrations of the osteological characters of the extinct form characterised by the labyrinthic structure of its teeth.

Species—*Labyrinthodon Jaegeri*, Owen.

The first of these fossils here described indicated a species as large as the type of *Mastodonsaurus*. It consisted of portions of two mandibular rami (*Batrachia*, Plate 2) from different individuals. One, figs. 1, 1*a*, includes the angular, articular, and hinder part of the dentary elements of the lower jaw, with portions of a score of relatively small conical, nearly equal-sized teeth. The angle of the jaw terminates obtusely, and is produced about three inches behind the articular surface.

[1] 'Ueber die fossilen Reptilien, welche in Würtemberg aufgefunden worden sind,' 4to, 1828, pp. 35, 38, tab. 4 and 5.

From this the bone gradually decreases in vertical extent to its broken fore end. In the second and larger fossil (fig. 2) the exterior of the lower three fourths of the bone is strongly sculptured by obtuse interrupted ridges, mainly radiating from the lower border below the articular surface (fig. 2). The inner side of the ramus (fig. 2) is comparatively smooth, and shows the termination of the depression which lodged the hind end of the dentary element. Portions of the maxillary bone and teeth of this species are shown in figs. 4, 5, and 6, Plate 4.

Species—*Labyrinthodon leptognathus.* (*Batrachia*, Plate 3.)

Of the fossils referred to the above species the most instructive was the portion of skull represented in figures 1 and 2, of the natural size. Careful removal of the stony matrix exposed, on the palatal surface (fig. 2) a broad divided vomer (*b*), contributing a somewhat larger proportion to the roof of the mouth, than the divided vomer characteristic of existing Toads and Frogs. The position and relative size of the inner or palatal nostril (*c*) added to the batrachian characters. Anterior to this part of the palate was the base of a tooth, which, compared with the row of maxillary teeth, might be termed a tusk. The labyrinthic structure was instructively shown in a section of this tooth. So much of the upper wall of the skull is preserved as to show the broad, flattened shape of its facial portion; but the extent of the maxillary and nasal bones composing the roof presents a marked distinction from the framework of the similarly shaped skull in existing broad and flat-headed Batrachians. In these the maxillaries have the form of elongate styles, attached by a slightly expanded fore end, and terminating behind in a free point: they are, also, edentulous.

The outer surface of the broad facial part of the skull of *Labyrinthodon* is sculptured in a degree recalling that of the outer surface of the lower jaw of the huge species above described. Irregular grooves and sinuses are divided by corresponding risings. An angular furrow runs nearly parallel with the alveolar process, a little above it, defining it from the broad upper flat surface of the skull; a second less angular furrow inclines one side as it extends forward.

The alveolar part of the fossil includes thirty-one sockets, the foremost, lodging the base of a tooth three times the size of the next, which commences the series of smaller teeth, gradually decreasing in size as they extend backwards. A side view of the above-described fossil is given in fig. 3, in which *a* indicates the tusk of the outer dental series and *b* that of the vomer.

The dental character of the present species is more fully shown in the considerable proportion of the left mandibular ramus, figured in *Batrachia*, Plate 4,

figs. 8 and 9. The conformity of this character with that shown in the preserved portion of the upper jaw will be appreciated by the side-view of that portion introduced in fig. 7 of Plate 4. In the vacant mandibular sockets, corresponding to the upper teeth in place, are germs of successional teeth, more or less advanced in formation. The number of sockets in the single alveolar series is not less than fifty: to which add a much larger canine or tusk at the inflected symphysial end. A Batrachian mandibular character is exaggerated in *Labyrinthodon* by the extension of the angular element of the jaw along the under part of the ramus to the short symphysis. The 'harmonia,' or toothless suture indenting the outer surface, indicates the proportions of the angular and dentary elements contributed to that surface. Figures of the best preserved maxillary and mandibular serial teeth, slightly magnified, are given in advance of the views, natural size, of the upper and lower jaws of *Labyrinthodon leptognathus*.

Labyrinthodon pachygnathus, Owen. (*Batrachia*, Plates 3 and 4.)

The portions of upper jaw on which this species is founded are represented of the natural size in figures 4, 5, 9, and 10 of Plate 3. The outer surface of the portion preserved of the maxillary shows the characteristic coarse sculpturing; part of the vomerine nostril is indicated at *c*, figs. 9 and 10. The alveolar and part of the palatal processes of the maxillary afford the subjects of figs. 4 and 5; and the crown of the best preserved maxillary tooth is represented in fig. 6. Figs. 7 and 8 are portions of a mandible, but the characters of this bone and of its teeth are exemplified in figs. 1, 2, 3 of *Batrachia*, Plate 4, from parts of the right ramus.

The outer surface of the dentary is traversed by a longitudinal groove midway between the upper and lower borders, indicative of the proportions of the dentary and angular elements thereto contributed. The part of the outer surface of the angular in the hinder portion of the mandible of *Lab. pachygnathus* is broken away. On the inner surface of the fore part of the ramus (fig. 2) is shown the pointed termination of the splenial element, which extends to near the symphysis; an upper view of the same fore end of the ramus is given in fig. 3. The mandibular dentition is instructively shown in the present specimens. The small serial teeth exhibited more or less entire, or indicated by sockets, in the two portions of jaw, are not fewer than forty. The symphysial end of the ramus supports two much larger tusk-like teeth, with indication of a third of less size, but exceeding that of the serial teeth. Of these the crown is best preserved in the posterior portion of the ramus (fig. 1), which had been detached from the rest. The

vacant sockets between the teeth in place show more or less advanced beginnings of successional teeth. The figures of the mandible and teeth are of the natural size.

Vertebræ of Labyrinthodon. (*Batrachia*, Plate 5.)

The proportions of a vertebral fragment, associated with the above-described mandible, in the Trias of Coton End, lead me to refer it to the species *pachygnathus*. Fig. 1, showing a portion of the fore articular surface of the centrum, with the coalesced base of the neural arch, gives the moderately concave character of that surface. The upper view of the same vertebral fragment (fig. 2) determines the fore and hind ends by the bases of the zygapophyses of the coalesced neural arch fortunately remaining. The base of a broad, depressed diapophysis is also shown, and is further exemplified in the side view (fig. 4). The hind articular surface of the centrum has suffered fracture, forbidding determination of its natural shape. The minutely cellular, almost compact, texture of the bone is displayed by the fractured surface in fig. 3.

A better preserved vertebra, in size referable to *Labyrinthodon leptognathus*, affords the subjects of figs. 5—8. The degree of concavity of the fore surface is shown in fig. 7, in which the centrum is associated with so much of the neural arch as exhibits the position and shape of the prezygapophyses which received the articular ends of the postzygapophyses, unfortunately mutilated, with the corresponding articular surface of the centrum, as shown in fig. 8. In the characters of the vertebra from a part of the trunk, as exemplified in the specimens from two of the British species of the present singular genus, we find the *Labyrinthodon* superadding modifications to the vertebræ of the highest existing *Batrachia* (toads, frogs, salamanders), which, as in the dental and osteological characters next to be noticed, manifest an association of Reptilian (Crocodilian, Dinosaurian) features with an essentially Batrachian organisation. The portions of ribs which have been recovered show these bones to have been of greater relative length and curvature than in any existing Batrachians, and in the character of size they accord with that of the articular process and surface developed from the neural arch.

The subject of figs. 9 and 10, in Plate 5, might well have been interpreted, if found alone, as evidence of an extinct Reptile of higher grade than a salamander,—to an *Icthyosaur*, for example. It is plainly a sternal bone, showing articular concavities for a pair of clavicles; or it may answer to that part of the complex scapular arch in Reptiles which has been named "episternum." The locality of the fossil and its associations with unquestionable remains of Labyrinthodont reptiles support its reference to that genus; and, from its size, to the species *leptognathus*. The stem or body of the bone thins off as it recedes from the

articular process to a flat plate, from which the end is broken away. The advanced thicker end expands and extends into cross pieces, at right angles, each with an articular depression indicative of clavicles. Now, these bones, which are absent in *Crocodilia*, are present in higher *Batrachia*, and, in *Bufonidæ*, their mesial extremities rest upon the expanded fore end of an episternal bone; it is not, however, curved lengthwise as shown in fig. 10, in *Labyrinthodon*, a curvature which indicates a greater vertical capacity of the fore part of the thoracic-abdominal cavity.

Humerus.

The fossil from the Trias at Coton End, of which four figures (11—14) are given in Plate 5, is the proximal portion of a humerus. The moderately-convex, proximal, articular end (fig. 14), from which extends the beginning of a well-developed deltoid ridge, and the characters of the shaft shown by the surfaces divided by that ridge, are more like those of the humerus of a toad than in that of any Lacertian, Chelonian, or Crocodilian Reptile. The bone had a medullary cavity of the width shown in fig. 13.

If this limb-bone should belong to the same species as the ilium (figs. 16 and 17) the disproportion of size in the fore and hind limbs would be as in the anourous Batrachians; but I have received evidences of the tail of *Labyrinthodon.*

Great part of the ilium is devoted to the formation of a large acetabular cavity; this is of an oblong form, extending in the long axis of the bone; its margin, elsewhere sharp, is smoothed away at the base of the iliac body, which becomes narrow and compressed as it recedes. The chief distinctive character is the process above the acetabulum, from which it is separated by a smooth concavity; this process is compressed as it rises, and is bent forward, ending in an obtuse point. A process of a different shape rises in a similar position above the acetabulum in the frog. From the superacetabular process the ilium is continued forward, and terminates in a thick subtruncate surface a few lines in advance of the acetabulum. The extent to which this ilium is articulated to the vertebræ, at least three in number, which may be regarded as sacral, is shown in the mesial view of the bone given in fig. 17; the superacetabular process and the hinder slender production contributing to the vertically concave articular surface.

Of a femur, corresponding in size, in any degree, with the above ilium, I have, as yet, received only the hemispherical head, represented in fig. 18. But in a group of bones of a small, or possibly young, Reptile from the New Red Sandstone (Trias) of Lymington, with the distal articular end of a femur (*Batrachia*, Plate 6, fig. 1, *f*), were associated a tibia (*t*) and a humerus (*h*), plainly indicating a great disproportion in size between the fore and hind limbs.

I subsequently found that a fossil from Warwickshire Trias, figured in Plate XXVIII, fig. 9, of the above-cited paper by Murchison and Strickland, was a terminal phalanx showing a Batrachian character in the absence of the usual modification for the insertion or attachment of a claw.

Labyrinthodon (*Anisopus*) *scutulatus*, Owen.

Returning to the group of bones in Plate 6, figs. 1—5, I found them to belong to a small reptile with the biconcave system of vertebræ, but which, from the length, structure, and form of the long bones of the extremities, must have been of terrestrial rather than marine habits, and which had the skin defended by numerous small rhomboidal bony scutes, with a smooth central surface, and with the outer surface sculptured by three or four longitudinal ridges (fig. 5). This reptile had the hind legs twice as long and as strong as the fore. The humerus (fig. 1, *h*) is convex at the proximal extremity, it is expanded both at this and the distal extremities, and is contracted in the middle. There is a portion of a somewhat shorter and flatter bone, bent at a subacute angle with the distal extremity of the humerus, and which presents the nearest resemblance to the anchylosed radius and ulna of the frog. The proximal extremity is wanting in the femur (fig. 1, *f*), the remnant of the shaft is slightly bent, and is subtrihedral; its walls are thin and compact, and include a large medullary cavity. Both tibiæ exhibit that remarkable compression of the distal portion of the shaft which characterises the corresponding bone in the anourous *Batrachia*, and both likewise exhibit the longitudinal impression along the middle of the flattened surface.

The vertebræ (figs. 2, 4, and 3 magnified) are biconcave, with these surfaces sloping obliquely from the axis of the body, as in the dorsals of a frog, indicative of habitual curvature of the part of the spine formed by them. The aquatic Salamanders, including the gigantic species from Japan, have both ends of the vertebral body concave, but more conical than hemispherical, as in the present fossil, which in this respect resembles the Labyrinthodont vertebræ (figs. 1 and 7) in Plate 5. Portions of ribs associated with the above-described fossils showed them to be longer and more curved than in the existing remnants of the Batrachian type.

The Leamington fossil also exhibits a character, in the small, bony dermal sculptured plates, not yet found in the Warwick or Wirtemberg Labyrinthodons, which seems to remove it from all *Batrachia*—the naked reptiles, as they are emphatically termed—and to approximate it to the Loricated Order. These scutes (fig. 5) form a suggestive instance of the Crocodilian affinities of the Leamington Batrachian; we have already seen the same affinities mani-

fested in other parts of their organisation by the larger Labyrinthodons. As these detached superficial bones are the most liable to be separated from the fragmentary skeleton of the individual they once clothed, the mere negative fact of their absence, when so small a porportion of the bones of the trunk of any *Labyrinthodon* has yet been found, is insufficient to prove a difference of dermal structure between the Leamington and Warwickshire species.

No anatomist, indeed, can contemplate the extensive development and bold sculpturing of the dermal surface of the cranial bones in the *Labyrinthodontes pachygnathus* and *leptognathus*, without a suspicion that the same character may have been manifested in bony plates of the skin in other parts of the body. And granting that this structure existed, to what extent, it may be asked, does it affect the claims of the *Labyrinthodon* to be admitted into the order of *Batrachia*, in which every known species is covered with a soft, lubricous, and naked integument? To this question it may be replied, that the skin is the seat of the most variable characters in all animals; and, if considered apart from the modifications of the osseous and dental systems, is apt to mislead the naturalist who is in quest of the real affinities of a species. Suppose, for example, that the existing Chelonian Reptiles were exclusively mud-tortoises, or with a soft and naked skin, as in the species of *Trionyx* and *Sphargis*, would the discovery of the osseous carapace of a true Testudo, in a fossil state, in connection with a skeleton in other respects essentially corresponding with the modifications exhibited by a Trionyx, prohibit the association of the fossil in the same order of Reptiles with the Trionyx, because of the indication of the scutes? It unquestionably ought not to affect such a determination. And so with respect to the Labyrinthodont Batrachia; if all the species have pushed their affinities to the Crocodilians so far as to have had their trunk defended by bony dermal plates, yet their double occipital condyle, their comparatively simple lower jaw, their large vomerine bones and teeth are decisive of their Batrachian nature.

In the "Alaunschiefer of the German Keuper" was found the occipital part of a fossil skull, with a double condyle to which the name *Salamandroïdes giganteus* was given by Jaeger. I am of opinion that, with the *Mastodonsaurus*, it was also a Labyrinthodont.

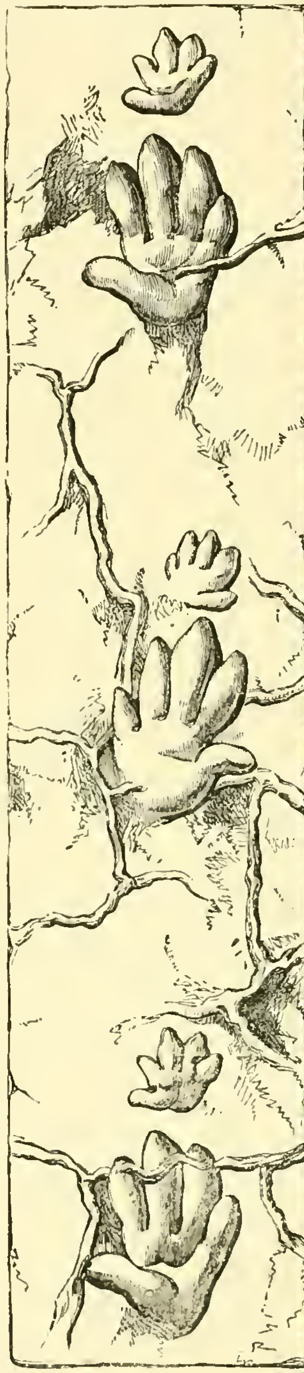
These extinct forms deviated from existing Salamanders in the crocodilian development and sculpturing of the cranial bones, and in having dermal osseous plates. Finally, I have to offer remarks on the Batrachian affinity indicated by their foot-prints.

Since the above-described fossils were submitted to my examination impressions and reliefs of impressions of foot-prints have been found on slabs of the New Red Sandstone in different British localities, proclaiming the primitive

plastic condition of such stones when so impressed at low water and receiving successive tidal deposits of the same fine sand.

Impressions and reliefs of such prints have been traced for many steps in succession, in one instance of which a portion is represented in the adjoining Cut. They have been noted in Triassic formations of Warwickshire and Cheshire, and in a quarry of whitish quartzose sandstone at Storeton Hill, a few miles from Liverpool. Some are hollow, as they were impressed, others are in relief, being natural casts; always, respectively, on opposite surfaces of the sandstone slabs.

Fig. 2.
Foot-prints of *Labyrinthodon.*



Such impressions or "ichnites" indicate vagrants of different sizes. Those left by the hind foot, in the largest kind, are eight inches in length, five inches in width; and near each, at a regular distance—about an inch and a half in advance—is a smaller print of the fore foot, four inches long and three inches wide. The footsteps follow each other in pairs at intervals of about fourteen inches from pair to pair. The large (hind) as well as the small (fore) steps show the thumb-like outer toe alternately on the right and left side, each step leaving a print of five toes, in which there are no indication of claws.

Foot-prints of this kind were first observed in Saxony, near Hillburghausen, in quarries of a Liassic sandstone. Dr. Kaup, who (1836) described them, gave the name of *Cheirotherium* to the animal that made them, in reference to their resemblance to the impression left by a human hand. But, led by a like disproportion between the fore and hind limbs in the kangaroo, he conjectured that they might indicate an extinct form of the Marsupial order of quadrupeds. In *Didelphys*, however, the thumb is on the inner, not the outer, side of the hind foot, and is on a line with the other toes in the fore foot.

Decisive evidence of a species of Mammal being in existence at the Triassic epoch has since been had; but the remains of *Tritylodon*[1] have not yet revealed the structure of the feet.

[1] 'Quarterly Journal of the Geological Society,' February, 1884, p. 146, Pl. VI.

The Cheirotherian Ichnites resemble the foot-prints of a Salamander in having the outer toe of the hind foot projecting at a right angle to the line of the mid-toe; they recall the foot-prints of the toad in their unequal size. The fossil remains, above described, from the Triassic deposits and localities exhibiting the Cheirotherian impressions, justify the conclusion that they have been made by a cold-blooded rather than a mammalian Marsupial animal, and by a species of the class which includes Batrachians with a similar disproportion between the hind and the fore limbs. On this hypothesis it is not less evident that the impressing vagrant was quite peculiar and distinct from any known Batrachian or other reptile in the form of its feet. The analogy of the Crocodilian reptiles would indicate the short and freely-projecting digit to be the outer or fifth toe, whilst the closer correspondence of the Batrachian feet would prove it to be the inner or first toe; but the thickness, relative size, and position of the remaining toes are peculiarities of the Cheirotherian footsteps.

Thus, in *Labyrinthodon* we have a Batrachian reptile, and one that differs very remarkably from all known Batrachia and every other reptile in the structure of its teeth: it is also a Batrachian, which, with strong affinities to the Sauria, appears to have presented the same inequality of size between the fore and hind extremities as does the so-called Cheirothere: and both the footsteps and the fossils are peculiar to certain members of the Triassic formations. May we not then be justified, upon this evidence, in adding the name *Cheirotherium* to *Mastodonsaurus* and *Phytosaurus* among the synonyms of the genus LABYRINTHODON?

I have already alluded to footsteps of a different but somewhat allied form, as being probably those of the *Lab. leptognathus.* These footsteps actually occur associated with those to which the name Cheirotherium has been given on the same slab, in the sandstone quarries at Storeton, but are more Crocodilian in their character.

Since my first acquaintance with this type of reptile I have received and described other specific and generic forms from Hindostan, America, and, as in the instance of the species of *Rytidosteus*, from a Triassic formation at the Cape of Good Hope.[1]

Here the progress of time compels me to conclude the present work. To those who encouraged me in the undertaking I plead the intervals elapsing between the acquisitions of the subjects, and the frequent indication of a new form of Extinct Reptile by a fragmentary fossil, calling for further research in the locality, and lapses of time before additional evidences justified a reconstruction and a name for the long lost monster.

[1] 'Quarterly Journal of the Geological Society,' March, 1884.

A glance at any summary of the *Reptilia* still maintaining an existence in Great Britain[1] will impress the contrast between them and the numbers, the hugeness, the strange modifications of such cold-blooded air-breathers which lived on the lands and swam by the shores of the Mesozoic and Eocene worlds. These discoveries suggest, also, the most probable correspondence of the climate of the ancient continents at those epochs with that of the countries where the crocodile, the alligator, the ghavial, the boas, and the larger chelonians still find conditions of existence.

Nevertheless, what most impresses the writer is a sense of the fragmentary nature of the present contribution to a restoration of such forms of past life, and the conviction of the extent of the field which, especially in the Mesozoic strata of our island, still remains for the cultivation of the Reptilian branch of Palæontology.

[1] Bell's 'British Reptiles,' 8vo., V. Voorst.

THE END.